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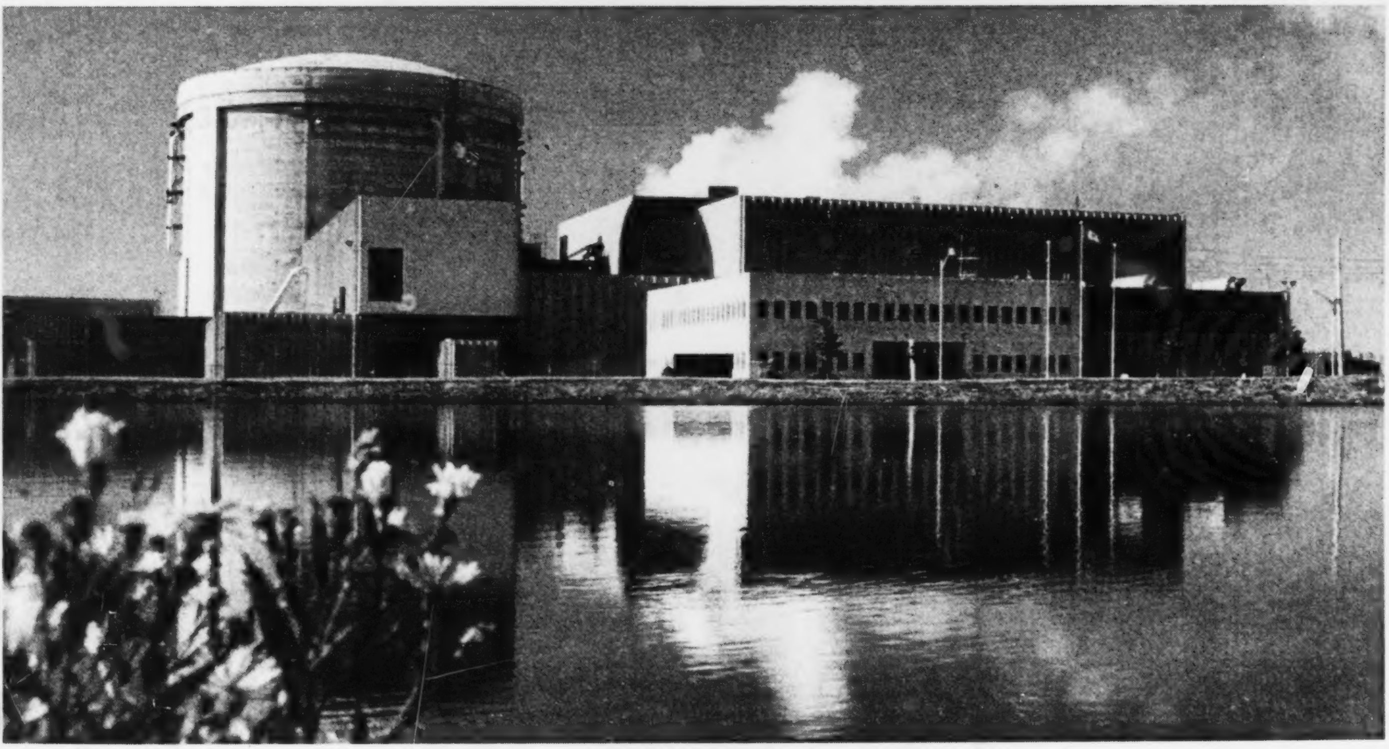
Point Lepreau Generating Station

POINT LEPREAU GENERATING STATION

Environmental Radiation Monitoring Data

January 1, 2002 to December 31, 2002



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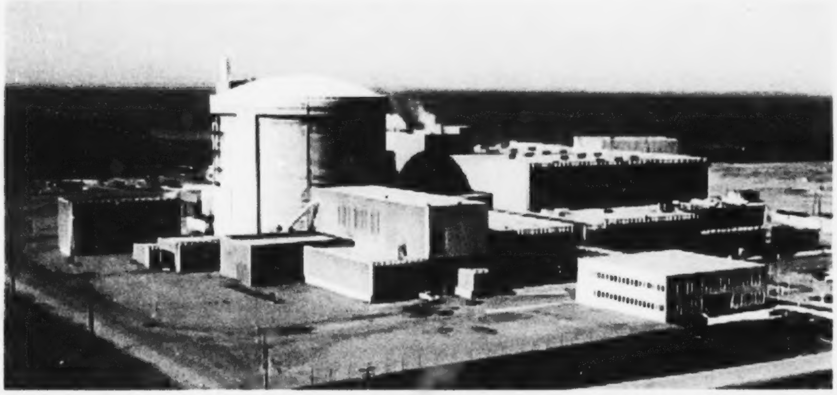

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Executive Summary

This annual report is a compilation of the 2002 results from the Environmental Radiation Monitoring Program for the Point Lepreau Generating Station (PLGS).

Since 1976, the monitoring program has analysed more than 28 000 samples to define background radiation from natural and human sources. The contribution from human sources has declined significantly since atmospheric bomb tests have ceased. The program detected radionuclide fallout in New Brunswick after a Chinese atmospheric bomb test in 1980, and fallout from the accident at Chernobyl in 1986. There have been no regionally detectable releases of radiation from any human activity since these two events.

In 2002, there were 1714 analyses on 1211 samples to monitor environmental radiation around Point Lepreau and across the province in general. There were 674 analyses performed on 537 other samples, including 589 analyses of 467 Quality Assurance (QA) samples. The analyses indicate that radiation dose from PLGS emissions continues to be well below the public dose limit (1000 microsieverts per annum), and also well below the design and operating target for PLGS (50 microsieverts per annum).

The only assessable radiation dose from PLGS to the local population is that from tritiated water vapour in air. As in past years, tritium continues to be detected offsite in air and water samples. The only trend that was obvious from the historical data was increasing H-3 in Parshall Flume water from the Solid Radioactive Waste Management Facility (SRWMF) Phase 1. However, starting in 2001, this trend was reversed.

Source of Dose to Critical Group	*Individual Dose (μSv/a)*
PLGS airborne emissions	0.35
PLGS liquid emissions	0.44
natural background (estimate)	2000

Several reports were near completion at the end of the year, including a study of groundwater movement, an ecological effects review, and an environmental assessment of the proposed SRWMF modifications (supporting PLGS refurbishment).

Another important initiative is the development of the PLGS Management System. This will control all activities that support PLGS. The environmental monitoring program falls under the primary process *SU-2 Provide Environmental Services*(1). This process was mapped in 2002, and all sub-processes related to routine environmental monitoring now come under it. As part of its overall Management System, Point Lepreau has an Environmental Management System (EMS)(2) in place that is registered to ISO 14001(3). Radiological releases to water and emissions to air are part of this.

The stated objectives of the program were met in 2002.

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1 Introduction

The licence to operate PLGS, issued by the Canadian Nuclear Safety Commission (CNSC), requires that NB Power maintain an Operational Environmental Radiation Monitoring Program (OERMP) during normal plant operations. This document describes the results of the program for the year 2002.

The requirement for this program is stated in *Radiation Protection Directives*(4) and *Solid Radioactive Waste Management Facility 2002 Safety Report*(5). The underlying reason for this is the large inventory of radionuclides that exist on site. The program operates in conjunction with *Liquid and Gaseous Effluent Monitoring Program*(6), which monitors and controls effluents at their source. The Derived Emission Limits (DELs) are calculated in *Derived Emission Limits for Radionuclides in Airborne and Liquid Effluents*(7).

As part of its overall Management System, Point Lepreau has an Environmental Management System (EMS) in place that is registered to ISO 14001. All activities and products that could impact the environment have been identified and logged in a database. From this, a list of significant environmental aspects (SEAs) was developed and it forms the foundation for the EMS. Management programs are in place for each of the SEAs to ensure compliance with the standards. The SEAs include radiological and non-radiological releases to water, emissions to air, waste management and accident management. Environmental assessment and improvement programs have been developed for the SEAs to ensure continual improvement.

All activities that support PLGS will be controlled by the PLGS Management System that is under development. The environmental monitoring program falls under the primary process *SU-02 Provide Environmental Services*. This process was mapped in 2002, and all sub-processes related to routine environmental monitoring now come under it.

Monitoring of the site began in 1976 with the Pre-operational Program(8), which became the OERMP in 1982(9). PLGS was declared "in-service" in February 1983. All radionuclide analyses in 2002 were performed in the Health Physics Environmental/Dosimetry Laboratory at 420 York Street, Fredericton, NB by the three full-time staff members (Health Physicist, Senior Technical Specialist and Technical Specialist).

The radiation monitoring program for PLGS is reviewed annually. This ensures that the samples collected, their frequency of collection, and the analytical techniques used are appropriate to achieve the objectives of the program. Late in 1999, the basis of the OERMP was extensively revised(10) to comply with *Guidelines for Radiological Monitoring of the Environment*(11), which did not exist when this program was first implemented.

The Environmental Radiation Monitoring Program for PLGS fulfils several objectives. These are to:

1) permit the estimation of dose to critical groups and populations from the radioactive emissions from PLGS and its Solid Radioactive Waste Management

Facility (SRWMF). This is achieved through the analyses of environmental and effluent samples.

2) provide data to confirm compliance of PLGS and the SRWMF with release guidelines and regulations and to provide public assurance of compliance. This is achieved through the issuance of the annual report to all interested parties.

3) establish and maintain the capability for environmental monitoring so that an effective response can be made to emergency conditions. This is achieved by maintaining the resources to step up the monitoring program during increased emissions that are only likely during an accident. The ability to interpret the data and make recommendations is also maintained.

4) maintain a database to facilitate the detection of trends. This is achieved by storing all results on a computer system that has the capability of reporting and graphing any desired subsets of the data.

5) verify or refine environmental models used in the calculation of Derived Emission Limits (DELs). This is achieved by comparing the theoretical dispersion factor with one calculated empirically. As well, other exposure routes to the public are continually evaluated.

6) determine the fate of released radioactive materials to show whether any significant pathway to humans has been overlooked. This is achieved through the collection and analysis of sample media outside of the established program. As well, any results that are not consistent with effluent results are investigated.

The capability of the radiation monitoring laboratory is assessed through the QA program. Analytical checks are also conducted daily. Indicator radionuclides, for example K-40 in milk, seawater and in other samples, show that the analyses are reproducible and that the operation of the laboratory has not changed significantly since it began.

The following sections will briefly describe the program. Details are provided on PLGS emissions, analyses results, trends, dose estimates, and the quality assurance program.

2 Point Lepreau Emission Data

Table 2.01 lists the production performance for PLGS since its beginning. Experience has shown that the years of lower capacity factors are usually the years with the lowest airborne emissions of most radionuclides, especially noble gases. The opposite is true for liquid emissions.

Table 2.01: PLGS Production Performance

Year	*Annual Gross Capacity Factor (%)*
1983	86
1984	90
1985	97
1986	94
1987	92
1988	96
1989	95
1990	96
1991	98
1992	87
1993	95
1994	94
1995	29
1996	83
1997	62
1998	68
1999	74
2000	71
2001	80
2002	68
Lifetime (Since In-service)	83

Emissions from PLGS continue to be at low levels as indicated in Table 2.02. By the time these releases reach the edge of the exclusion zone, they are diluted below the detection limits of most analytical procedures. Laboratory staff monitor the results of the emissions programs so that adjustments can be made to sampling and analysis protocols. There were no unusual emissions during the year 2002.

Table 2.02: Radionuclides Detected in Effluents

Nuclide	*Gaseous Effluent DEL (Bq/a)*	*Release (Bq)*	*Liquid Effluent DEL (Bq/a)*	*Release (Bq)*
H-3	4.3E+17	1.3E+14	1.6E+19	1.4E+14
C-14	3.3E+15	2.9E+11	3.0E+14	3.4E+09
Na-24	5.6E+15		-----------	
Ar-41	6.4E+16	2.2E+12	-----------	
Sc-46	1.7E+14		-----------	
Cr-51	2.4E+16		2.2E+15	9.6E+07
Mn-54	1.1E+14		6.4E+13	1.1E+07
Fe-55	-----------		5.1E+14	
Fe-59	4.0E+14		3.1E+13	5.4E+07
Co-58	3.0E+14		7.5E+13	
Co-60	6.5E+12		1.8E+13	3.4E+08
Zn-65	7.1E+13		1.5E+13	2.5E+07
As-76	-----------		3.2E+14	
Kr-85	1.9E+19		-----------	
Kr-85m	5.2E+17	3.3E+10	-----------	
Kr-87	9.4E+16		-----------	
Kr-88	2.8E+16		-----------	
Sr-89	3.7E+14		4.4E+16	
Sr-90	1.2E+13	1.0E+4	2.2E+15	2.3E+06
Y-90	8.2E+15		4.0E+15	
Y-91	-----------		3.1E+15	
Zr-95	1.7E+14		3.7E+13	3.9E+08
Nb-95	1.3E+14		1.1E+14	7.3E+08
Mo-99	5.4E+15		1.3E+16	
Ru-103	1.2E+15		1.8E+14	
Ru-106	7.7E+13		2.7E+14	3.5E+05
Ag-110m	3.8E+13		1.8E+13	3.5E+06
Sb-122	-----------		1.8E+14	1.0E+08
Sb-124	2.5E+14		4.8E+13	8.0E+08
Sb-125	-----------		1.9E+14	2.7E+08
Te-132	1.4E+15		2.9E+13	
I-123	-----------		4.2E+16	

Table 2.02 (continued): Radionuclides Detected in Effluents

Nuclide	*Gaseous Effluent DEL (Bq/a)*	*Release (Bq)*	*Liquid Effluent DEL (Bq/a)*	*Release (Bq)*
I-125	-----------		2.3E+14	
I-129	-----------		1.9E+13	
I-131	2.2E+13		3.0E+14	3.9E+06
I-132	1.5E+16		2.4E+16	
I-133	8.9E+14		3.5E+15	
I-134	1.9E+16		3.6E+17	
I-135	7.7E+15		9.2E+15	
Xe-131m	9.9E+18	1.9E+10	-----------	
Xe-133	2.4E+18	4.2E+12	-----------	
Xe-133m	2.8E+18		-----------	
Xe-135	3.4E+17	8.3E+11	-----------	
Xe-135m	2.0E+17	7.7E+09	-----------	
Xe-138	2.2E+16	5.0E+09	-----------	
Cs-134	1.9E+13		2.5E+14	
Cs-135	-----------		3.4E+15	
Cs-136	-----------		6.3E+14	
Cs-137	5.4E+12		4.0E+14	3.9E+06
Ba-140	7.4E+14		9.4E+15	
La-140	1.1E+16		4.7E+14	
Ce-141	2.1E+15		7.4E+14	
Ce-144	1.1E+14		2.8E+14	
Np-239	1.0E+16		-----------	
Noble Gas	7.3E+16 (Bq-MeV)		-----------	
Cu-64	-----------		-----------	1.8E+07
Sn-113	-----------		-----------	
Xe-137	-----------	3.9E+09	-----------	
Gd-153	-----------		-----------	8.1E+07
Gd-159	-----------		-----------	2.0E+06
Tb-160	-----------		-----------	4.5E+07
Hf-181	-----------		-----------	9.2E+05
W-187	-----------		-----------	2.3E+06
Alpha	-----------		-----------	2.8E+07
Beta	-----------		-----------	2.7E+08

Releases from some locations require the use of a different DEL to compensate for flow rates.

3 Sample Media, Locations and Frequencies

The data contained in this report are for samples collected from January 1 to December 31, 2002, with some overlap for air, precipitation and thermoluminescent dosimeter (TLD) samples. During this time, the major media analysed and their frequency of collection were as indicated in Table 3.01. Sample collection usually takes place at least once each week throughout the year. The number of each sample type and the major radionuclide measurements performed are listed in Table 3.02.

The miscellaneous samples include those that do not readily fit into any of these listed categories or are not routinely collected. These include numerous in-station samples (e.g., drinking water) relating to the operation of PLGS.

The major sample locations are listed in Table 3.03 (details in Appendix C) and shown in Figures 3.02 to 3.05. Each "Indicator" site has a three or four-character identification code (e.g., F01, I10A). An Indicator site is one within the possible influence of PLGS emissions. "Reference" locations, chosen to lie outside the influence of PLGS emissions, are identified by the letter R at the end of the location code (e.g., A01R).

Sample locations for mobile seafood species (lobster, fish, etc.) caught in the Point Lepreau area are specified as accurately as reasonably possible. The location of capture, however, may bear little relationship to where the animal has been in the recent past. The availability of such samples is not generally predictable and is outside of the control of the laboratory.

Table 3.01: Schedule of Sample Collection and Analysis

Sample Medium	*Typical Frequency*
Atmospheric Sampling	
Airborne Particulates	Monthly (integrated sample)
Airborne Iodines	Monthly (integrated sample)
Airborne Water Vapour	Monthly (integrated sample)
Airborne Carbon Dioxide	Monthly (integrated sample)
Ambient Gamma (TLDs)	Quarterly (integrated sample)
Gaseous Effluent Monitor (GEM) Filters	Weekly Composite (integrated sample)
Terrestrial Sampling	
Ambient Gamma (TLDs)	Quarterly (integrated sample)
Milk - commercial dairy - dairy farms	Monthly Quarterly
Well Water	Semi-annually
Pond, Puddle and Surface Water	Quarterly
Berries	Weekly in Season
Garden Vegetables	Weekly in Season
Vegetation	Quarterly
Soil	Quarterly
Near Plant Monitoring Wells	Three Times Per Year
Precipitation	Monthly (integrated sample)
Marine Sampling	
Seawater	Quarterly
Clams	Quarterly When Available
Fish	Quarterly When Available
Lobster	Quarterly When Available
Periwinkles	Quarterly When Available
Aquaculture Salmon	Quarterly When Available
Scallops	Quarterly When Available
Crabs	Quarterly When Available
Dulse	Quarterly When Available
Other Sea Plants	Quarterly
Sediment	Quarterly
Gamma Surveys (Beaches)	Quarterly
Liquid Effluent Monitor (LEM) Composite	Monthly Composite (integrated sample)

Table 3.01 (continued): Schedule of Sample Collection and Analysis

Sample Medium	*Typical Frequency*
Solid Radioactive Waste Management Facility	
Bore Hole Water	Three Times Per Year
Parshall Flume Water	Weekly
Ambient Gamma (TLDs)	Quarterly (integrated sample)
Hemlock Knoll Regional Sanitary Landfill	
Bore Hole Water	Semi-annually
Water (leachate and settling/holding ponds)	Monthly to Semi-annually
Ambient Gamma (TLDs)	Quarterly (integrated sample)

Table 3.02: Sample Information

Sample Medium	*Number of Samples*	*Radionuclide Measurements*
Atmospheric Sampling		
Airborne Particulates	95	gamma emitters & gross alpha/beta
Airborne Iodines	95	I-130,131,132,133,135
Airborne Water Vapour	95	H-3
Airborne Carbon Dioxide	34	C-14
Ambient Gamma (TLDs)*	107*	gamma exposure
GEM Filters	52	Sr-89,90 & gamma emitters
Terrestrial Sampling		
Ambient Gamma (TLDs)*	107*	gamma exposure
Milk - commercial dairy - dairy farms	12 13	gamma emitters & H-3
Well Water	31	gamma emitters, gross alpha/beta & H-3
Pond, Puddle and Surface Water	16	gamma emitters & H-3
Berries	4	gamma emitters
Garden Vegetables	17	gamma emitters
Vegetation	16	gamma emitters
Soil	38	gamma emitters
Near Plant Monitoring Wells	33	gamma emitters & H-3
Precipitation	49	gamma emitters & H-3
Marine Sampling		
Seawater	16	gamma emitters & H-3
Clams	10	gamma emitters
Fish	0	gamma emitters
Lobster	6	gamma emitters
Periwinkles	12	gamma emitters
Aquaculture Salmon	2	gamma emitters
Scallops	1	gamma emitters
Crabs	1	gamma emitters
Dulse	8	gamma emitters
Other Sea Plants	12	gamma emitters
Sediment	39	gamma emitters
Gamma Surveys (Beaches)	39	gamma exposure
LEM Composite	12	Sr-89,90, gamma emitters, gross alpha/beta

*One TLD measures the gamma dose from radionuclides in the air and on the ground.

Table 3.02 (continued): Sample Information

Sample Medium	*Number of Samples*	*Radionuclide Measurements*
Solid Radioactive Waste Management Facility		
Bore Hole Water	67	gamma emitters & H-3
Parshall Flume Water	107	gamma emitters & H-3
Ambient Gamma (TLDs)	181	gamma exposure
Hemlock Knoll Regional Sanitary Landfill		
Bore Hole Water	15	gamma emitters & H-3
Water (leachate and settling/holding ponds)	20	gamma emitters & H-3
Ambient Gamma (TLDs)	20	gamma exposure
Other		
Miscellaneous	70	as required
Quality Assurance	339	as scheduled

Table 3.03: General Location Codes

Code	***Location***
A	West of Pennfield Ridge
B	Pennfield to New River Beach (inclusive)
C	Lepreau and Lepreau Harbour
D	Little Lepreau and Little Lepreau Basin
E	Maces Bay
F	Welch Cove
G	Pt. Lepreau lighthouse and surrounding area
H	Duck Cove
I	PLGS site – northeast quadrant
J	PLGS site – southeast quadrant
K	PLGS site – southwest quadrant
L	PLGS site – northwest quadrant
M	PLGS
N	Dipper Harbour
P	East of Dipper Harbour East to Musquash
Q	Lorneville
S	Saint John and surrounding area
T	Taymouth
X	Fredericton and surrounding area
Y	Hemlock Knoll Regional Sanitary Landfill

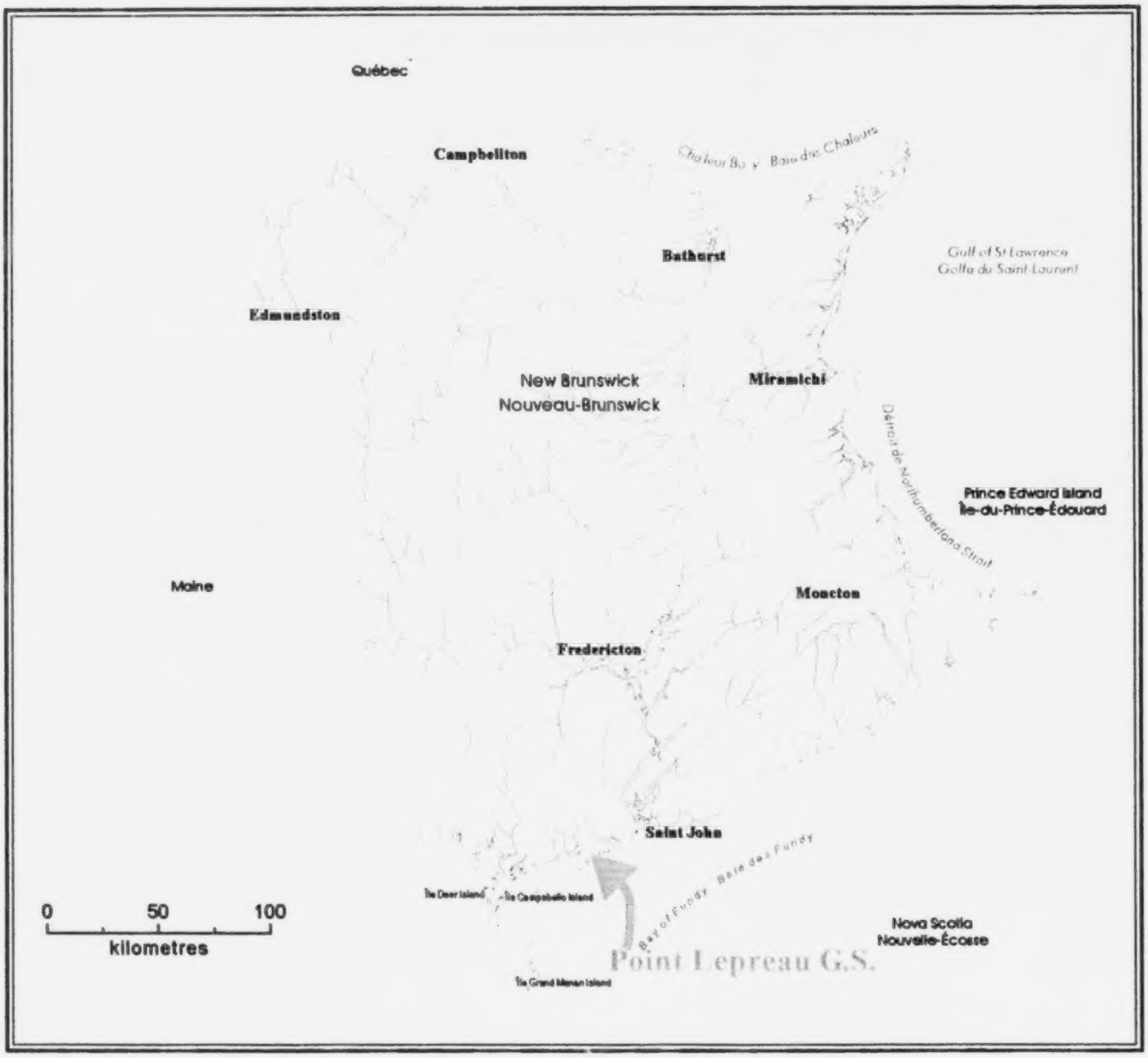
Québec
Campbellton
Chaleur Bay Baie des Chaleurs
Bathurst
Gulf of St Lawrence
Golfe du Saint-Laurent
Edmundston
New Brunswick
Nouveau-Brunswick
Miramichi
Détroit de Northumberland Strait
Prince Edward Island
Île-du-Prince-Édouard
Maine
Moncton
Fredericton
Saint John
Bay of Fundy Baie des Fundy
Île Deer Island
Île Campobello Island
0
50
100
kilometres
Nova Scotia
Nouvelle-Écosse
Point Lepreau G.S.
Île Grand Manan Island

Figure 3.01: Map of New Brunswick

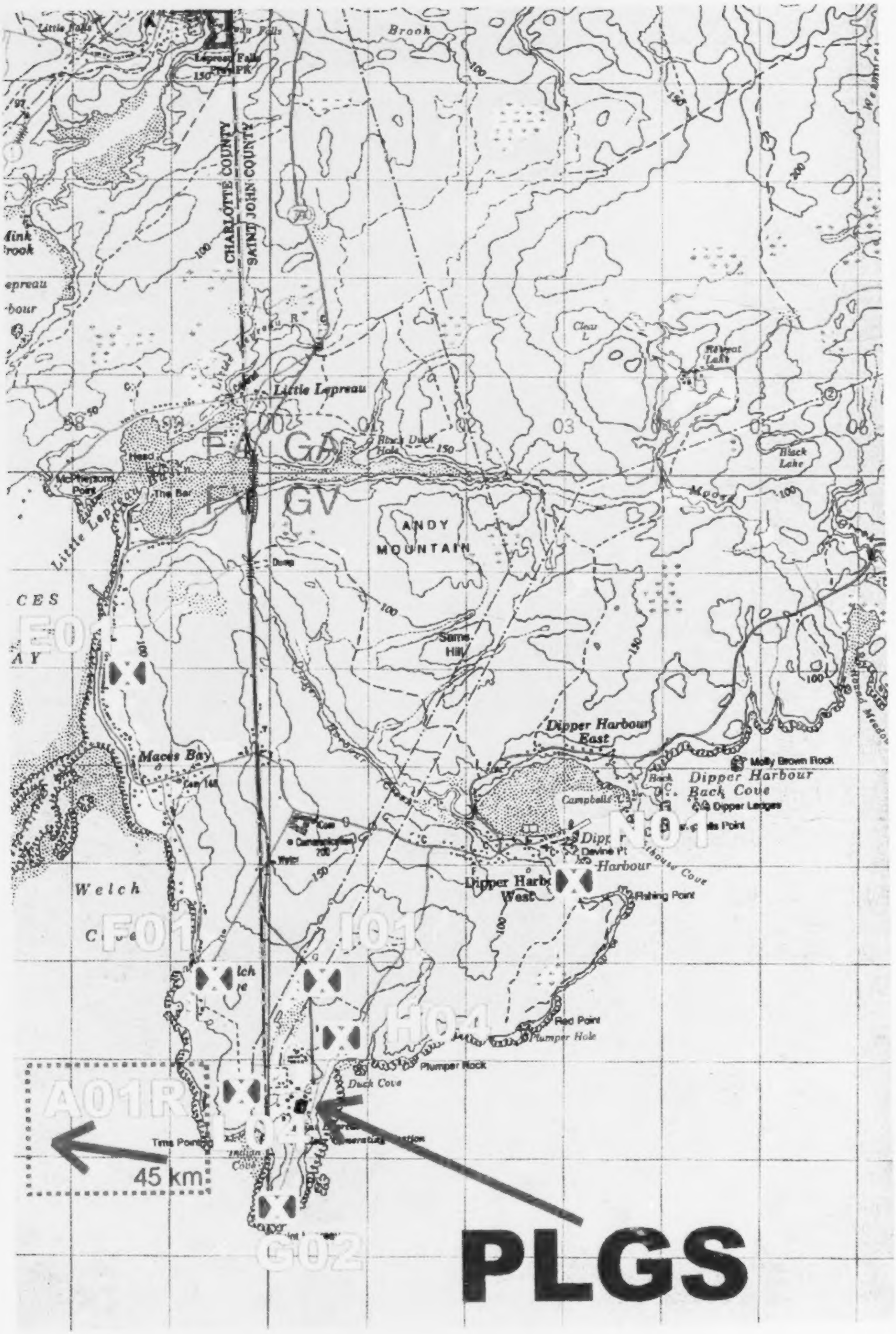
E01
F01
I01
H04
N01
A01R
45 km
G02
PLGS
FA
GA
FV
GV
ANDY MOUNTAIN
Little Lepreau
Maces Bay
Dipper Harbour East
Dipper Harbour West
Dipper Harbour Back Cove
Welch Cove
CHARLOTTE COUNTY
SAINT JOHN COUNTY
Black Lake
Red Point
Plumper Rock
Duck Cove

Figure 3.02: Air Monitoring Stations

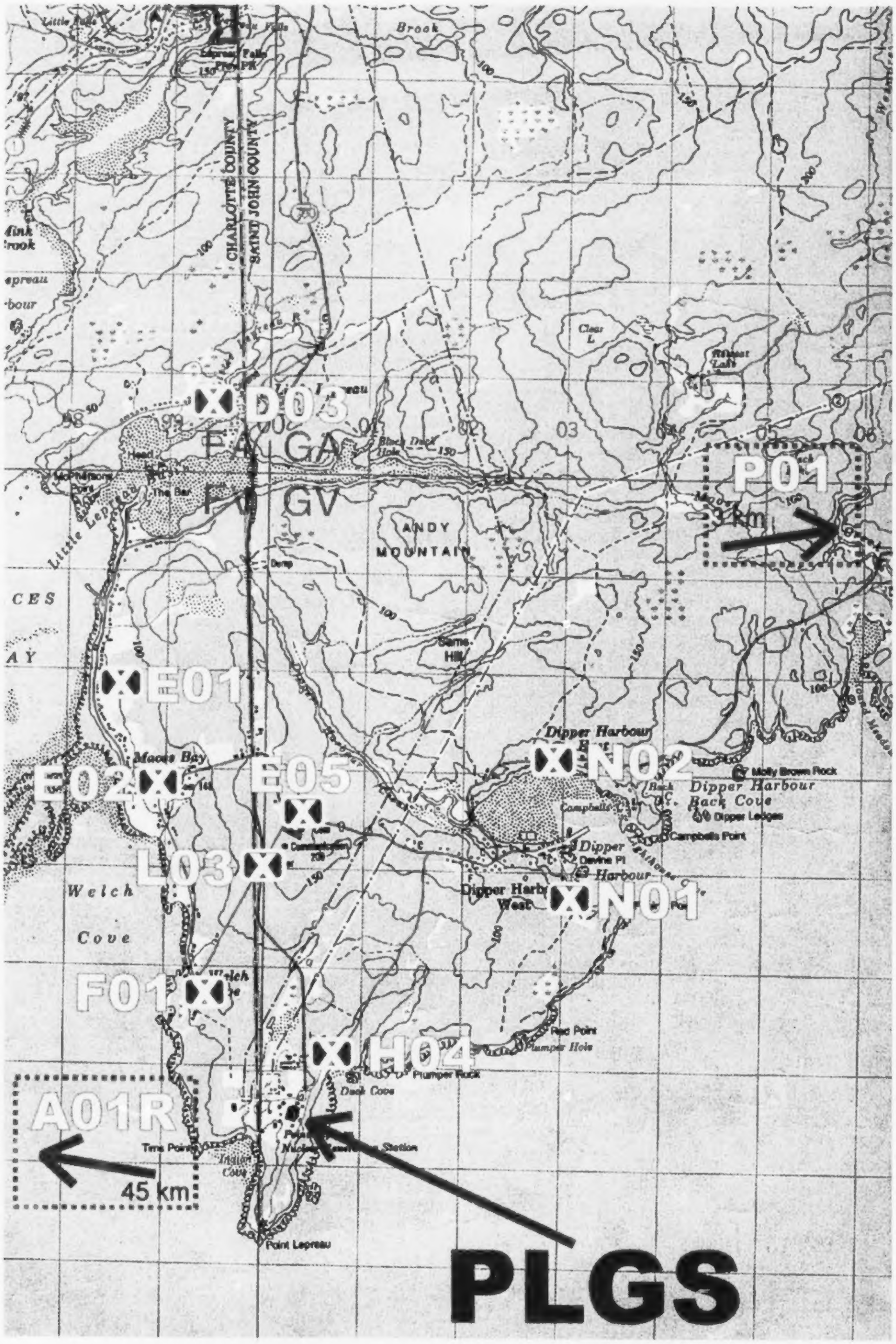
D03
FA
GA
FU
GV
P01
3 km
ANDY MOUNTAIN
E01
E02
E05
L03
N02
N01
F01
H04
A01R
45 km
PLGS
CHARLOTTE COUNTY
SAINT JOHN COUNTY
Maces Bay
Welch Cove
Dipper Harbour East
Dipper Harbour
Dipper Harbour West
Dipper Harbour Back Cove
Molly Brown Rock
Dipper Ledges
Campbells Point
Red Point
Plumper Hole
Plumper Rock
Duck Cove
Point Lepreau
Little Lepreau
Black Duck Hole
Clear L
Brook

Figure 3.03: Well Water Sites

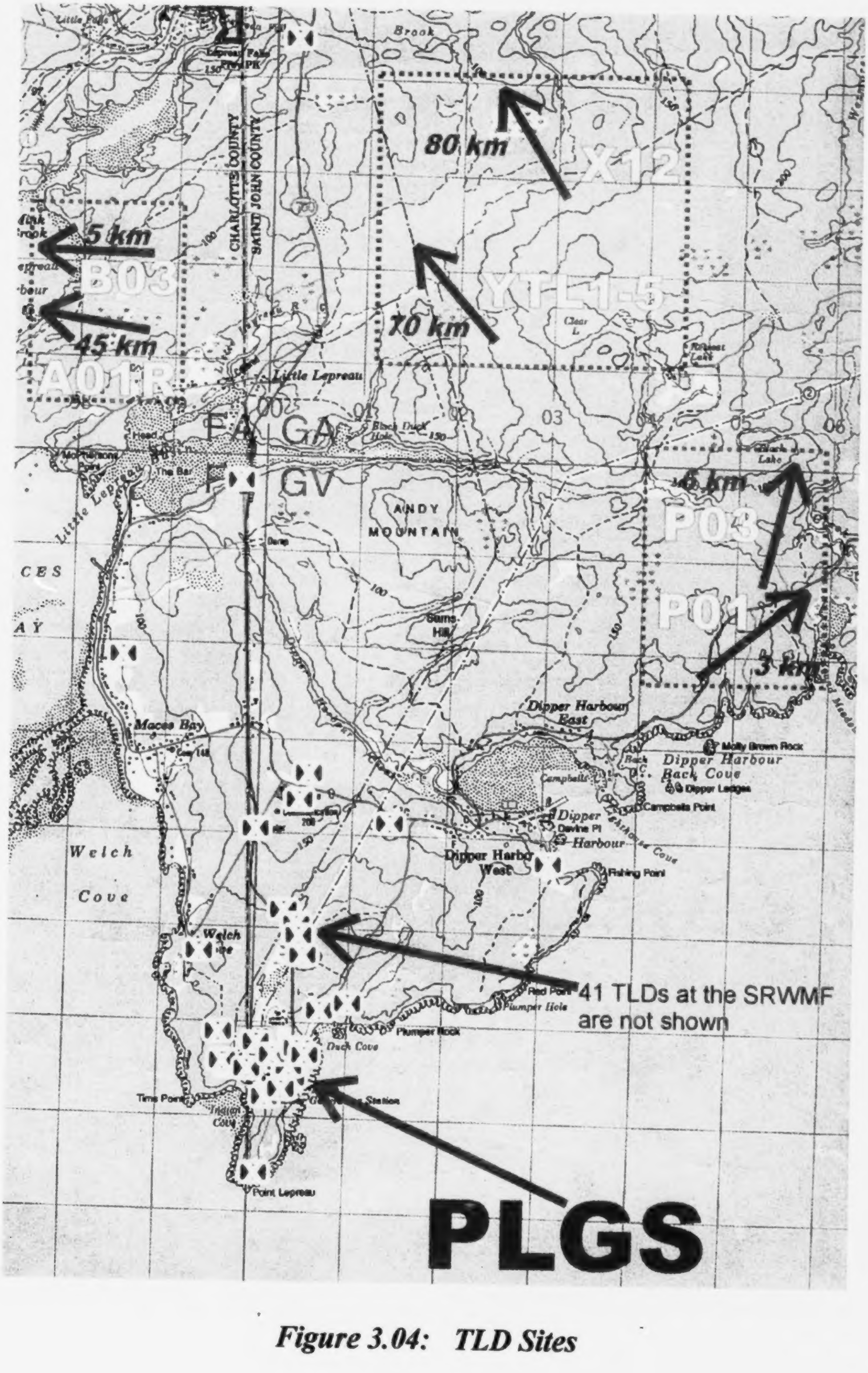
80 km
X12
5 km
B03
45 km
A01R
70 km
YTL1-5
CHARLOTTE COUNTY
SAINT JOHN COUNTY
Little Lepreau
FA
GA
F
GV
ANDY MOUNTAIN
6 km
P03
P01
3 km
Maces Bay
Welch Cove
Dipper Harbour East
Dipper Harbour
Dipper Harbour West
Duck Cove
Plumper Rock
Point Lepreau
41 TLDs at the SRWMF are not shown
PLGS

Figure 3.04: TLD Sites

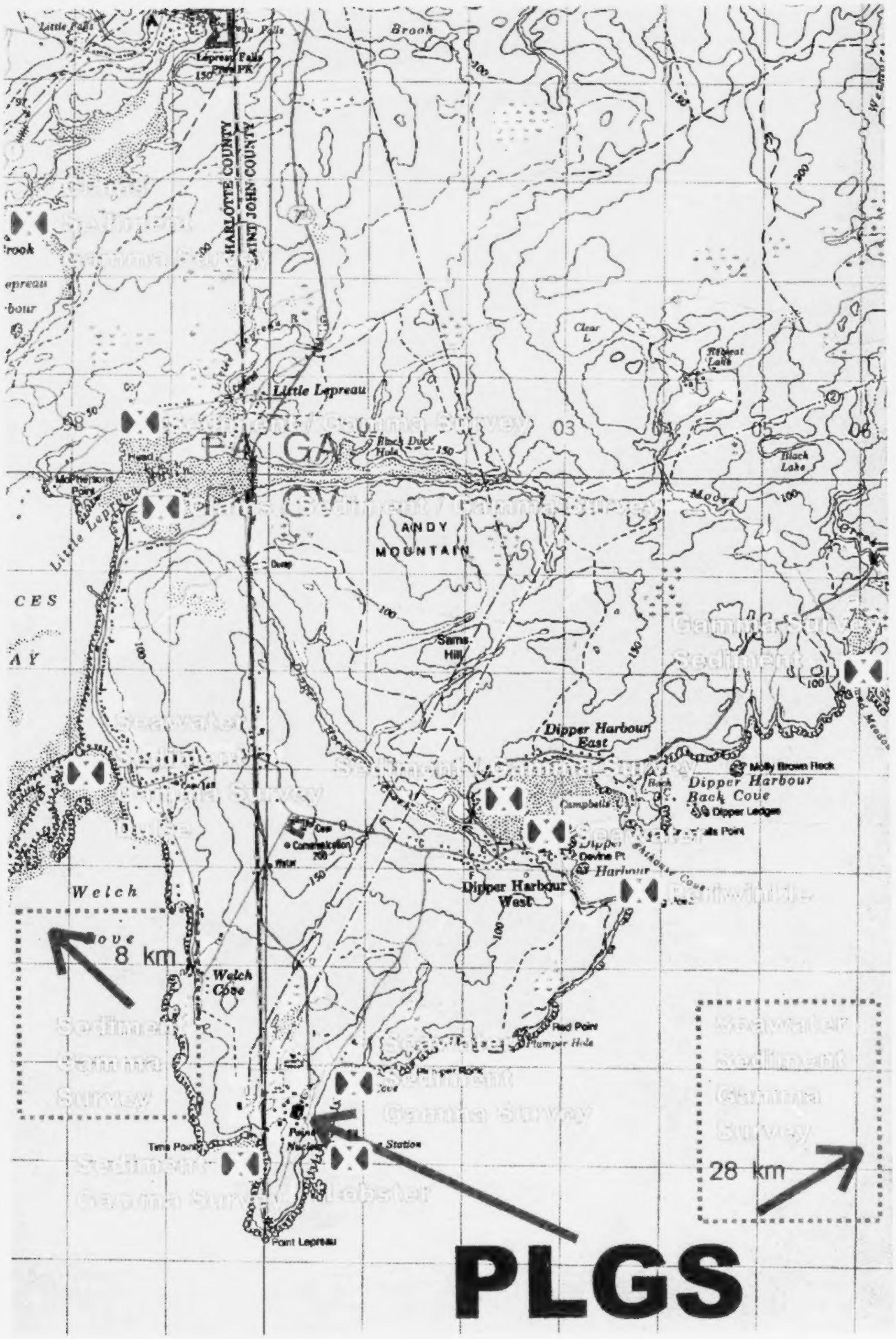
Little Lepreau
CHARLOTTE COUNTY
SAINT JOHN COUNTY
Sediment / Gamma Survey
Clams / Sediment / Gamma Survey
ANDY MOUNTAIN
McPherson Point
Black Duck Hole
Clear L
Black Lake
Sams Hill
Gamma Survey
Sediment
Seawater
Sediment
Gamma Survey
Dulse
Sediment / Gamma Survey
Dipper Harbour East
Dipper Harbour West
Dipper Harbour Back Cove
Molly Brown Rock
Dipper Ledges
Campbells
Seawater
Periwinkle
Welch Cove
8 km
Sediment
Gamma
Survey
Red Point
Seawater
Sediment
Gamma Survey
Tims Point
Point Lepreau
Sediment
Gamma Survey
Lobster
Seawater
Sediment
Gamma
Survey
28 km
PLGS

Figure 3.05: Marine Monitoring Sites

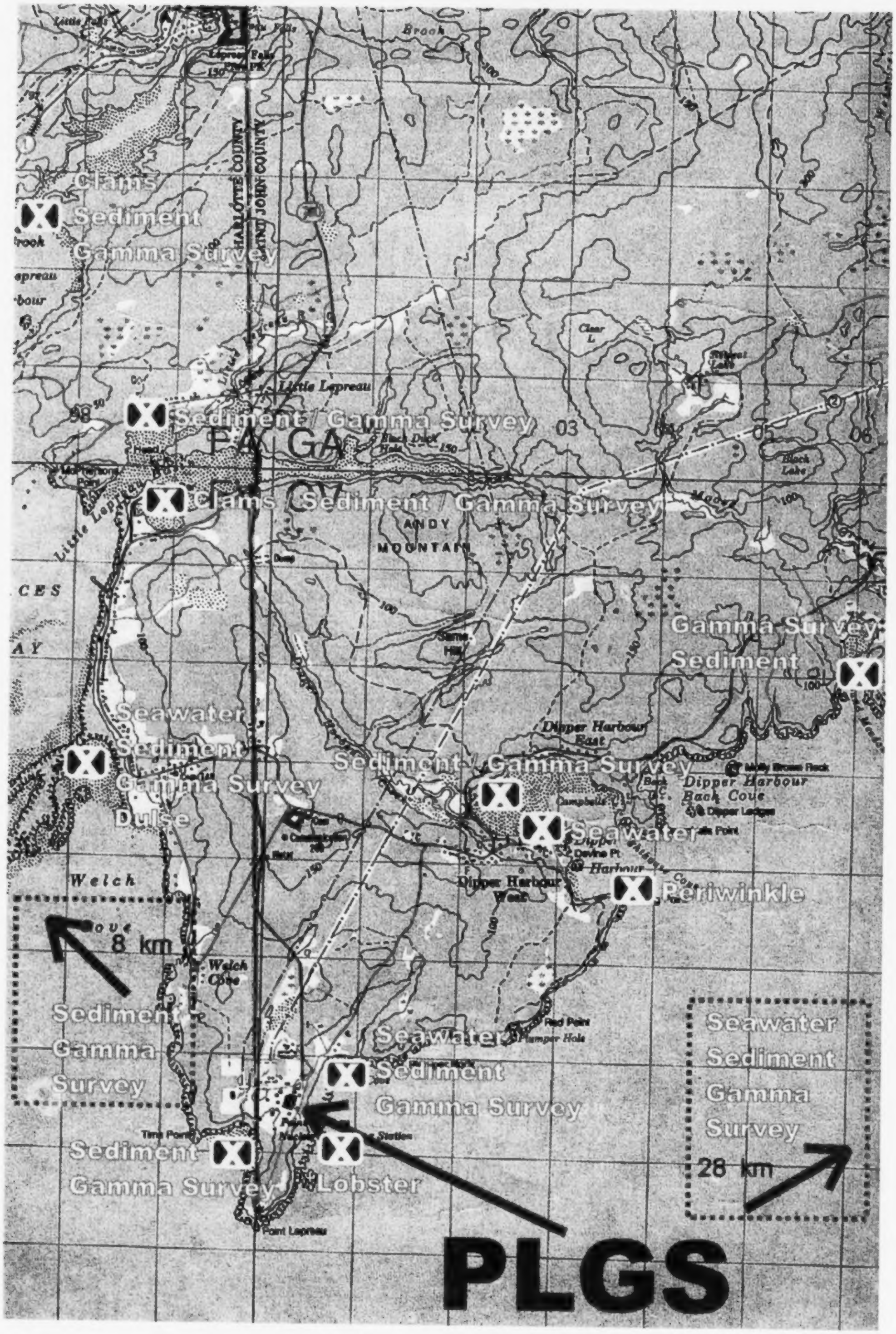
Clams
Sediment
Gamma Survey
Sediment / Gamma Survey
Clams / Sediment / Gamma Survey
Gamma Survey
Sediment
Seawater
Sediment
Gamma Survey
Dulse
Sediment / Gamma Survey
Seawater
Periwinkle
8 km
Sediment
Gamma
Survey
Seawater
Sediment
Gamma Survey
Sediment
Gamma Survey
Lobster
Seawater
Sediment
Gamma
Survey
28 km
PLGS
Little Lepreau
Dipper Harbour East
Dipper Harbour Back Cove
Dipper Harbour West
Welch Cove
Point Lepreau
CHARLOTTE COUNTY
SAINT JOHN COUNTY

Figure 3.05: Marine Monitoring Sites

4 Summary and Discussion of Data

The following is a summary and discussion of the data on environmental samples collected for the year 2002.

Most samples contained detectable levels of naturally occurring K-40 or cosmogenically produced Be-7. Some contained Cs-137 (soils, sediments, lichen) from the atmospheric bomb tests of past years and the Chernobyl accident. Tritium (in air and fresh water) is the only radionuclide originating from PLGS that is detected consistently. In 2002, analyses that indicated emissions traceable to PLGS were:

- H-3 in airborne water vapour and fresh water
- TLD measurements at onsite locations
- H-3 in Parshall flume and bore hole water from the Solid Radioactive Waste Management Facility (SRWMF)
- H-3 in water from onsite monitoring wells

The only assessable radiation dose from PLGS on the local population is that from tritiated water vapour in air. Offsite, the activity of H-3 in air ranges from less than about 2E-2 Bq/m^3 (below the lower limit of detection by the method used) to about 1.4 Bq/m^3 of air. The natural concentration of H-3 is up to 0.7 Bq/L in most surface waters and up to 1E-3 Bq/m^3 in air.

The natural concentration of C-14 in the atmosphere is approximately 4E-2 Bq/m^3. This level is usually detected by the sensitive analytical method used in the monitoring program.

Only detected radionuclides are listed in the following tables. Refer to Tables A.01 to A.11 in Appendix A for detailed listings of detection limits. Refer to Appendix C for a listing of location codes. Most tables contain the following data:

Column 1 - Shows the type of analysis or nuclide.

Column 2 - Shows the total number of samples analysed.

Column 3 – Shows the mean of the Critical Levels (CLs) for all samples. Any measurement greater than the CL is considered detected at the 99% confidence level (an explanation of the statistical protocol is given in Appendix A).

Column 4 - Shows the range of the Critical Levels (CLs) for all samples. Any measurement greater than the CL is considered detected at the 99% confidence level (an explanation of the statistical protocol is given in Appendix A).

Column 5 - Shows the mean of the detected values (i.e., values exceeding the CL) for all Indicator stations.

Column 6 - Shows the ratio of the number of detected values to the total number of Indicator samples.

Column 7 - Shows the range of detected values for the Indicator stations.

Column 8 - Shows the mean of detected values at the Reference location(s).

Column 9 - Shows the ratio of detected values to the total number of samples at this location.

Column 10 - Shows the range of detected values for the Reference location(s).

4.01 Airborne Particulates

There were no detectable airborne particulate radionuclides that could be attributed to the operation of PLGS on any of the 95 air filters analysed.

Air is continuously monitored from the eight locations shown in Figure 3.02. Once a month the filters are changed and analysed. There were 29 collection days lost at L04 due to an electrical supply problem.

Gross alpha and gross beta measurements are an indication of total activity in the environment. This includes naturally occurring radon progeny, cosmogenic (Be-7), and man-made sources of radiation. The maximum concentration of gross beta in air onsite was 6.0E-4 Bq/m^3 of air. Offsite it reached 5.4E-4 Bq/m^3. Table 4.01 is a summary of detected radionuclides. Figures 4.01 and 4.02 show the gross beta results for each location throughout the year. There is a slight seasonal trend in the data.

Table 4.01: Airborne Particulates (Bq/m^3)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
Alpha	95	3.4E-6	1.4E-6 to 1.1E-5	2.1E-5	82/83	5.3E-6 to 6.1E-5	2.4E-5	12/12	1.2E-5 to 5.0E-5
Beta	95	6.4E-6	2.5E-6 to 1.9E-5	2.4E-4	83/83	5.6E-5 to 6.0E-4	3.1E-4	12/12	2.1E-4 to 5.4E-4
Be-7	95	3.0E-4	4.2E-5 to 8.7E-4	9.2E-4	81/83	1.9E-4 to 2.2E-3	1.2E-3	12/12	6.3E-4 to 1.7E-3

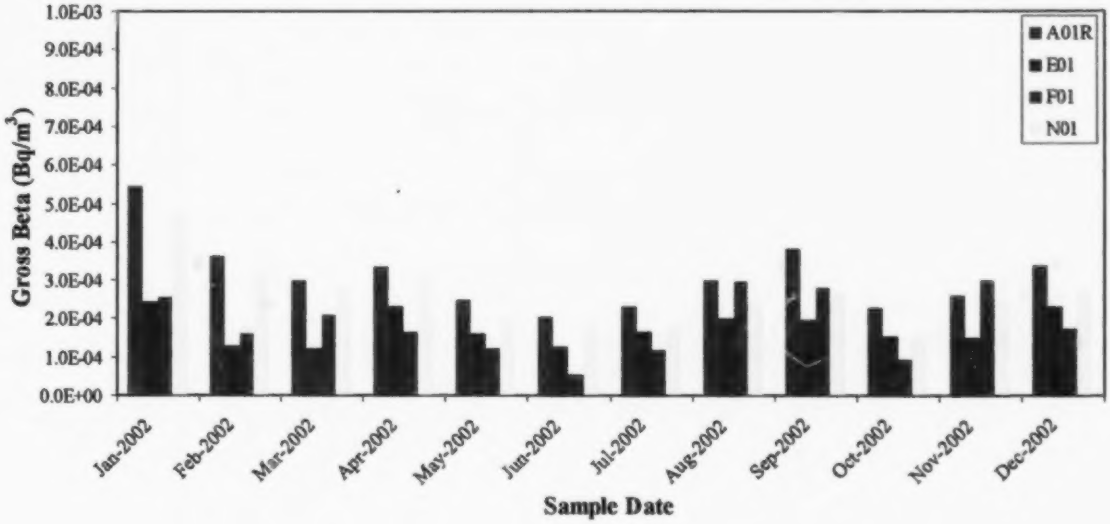

Figure 4.01: Gross Beta in Air for Each Offsite Air Station

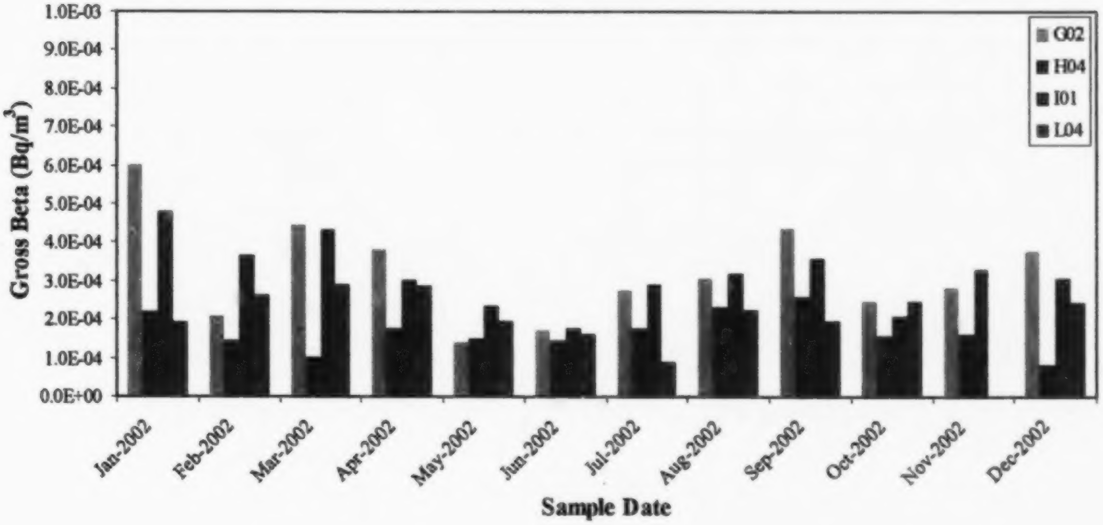

Figure 4.02: Gross Beta in Air for Each Onsite Air Station

4.02 Airborne Iodines

There were no detectable airborne radioiodines in any of the 95 samples analysed.

Air is monitored continuously, using charcoal cartridges, from the eight locations shown in Figure 3.02. Once a month the cartridges are changed and analysed. There were 29 collection days lost at L04 due to an electrical supply problem.

Iodine-131 was consistently below the Critical Level (average 8.4E-6 Bq/m^3).

4.03 Water Vapour

Tritium was detected in 73 of the 83 samples collected from the air monitoring stations on the Point Lepreau peninsula, and was detected in one of the 12 samples at the reference location.

Water vapour is collected continuously in molecular sieve bombs from the eight locations shown in Figure 3.02. Once a month the bombs are changed and analysed. There were 29 collection days lost at L04 due to an electrical supply problem.

The maximum concentration of tritium in air onsite was 2.7 Bq/m^3 of air. Offsite it reached 1.4 Bq/m^3. Tritium has been detected from time to time at the reference location, even before PLGS became operational.

Table 4.02 is the summary table of 2002 tritium data and Table 4.03 gives details of 2002 tritium results by location. Figures 4.03 and 4.04 show the H-3 results for each location. "Less Than" values are plotted for non-detected results. Locations to the northeast (H04, I01 and N01) have elevated H-3 measurements in the warmer months due to the predominant summer wind direction, which changes in the winter to impact the southwest locations (G02 and L04).

Table 4.02: Water Vapour - Tritium (Bq/m³)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
H-3	95	5.8E-2	1.6E-2 to 1.4E-1	7.5E-1	73/83	4.4E-2 to 2.7E+0	1.0.E-1	1/12	1.0E-1 to 1.0E-1

Table 4.03: Water Vapour - Tritium (Bq/m^3)

Location Code		***A01R***	***E01***	***F01***	***G02***	***H04***	***I01***	***L04***	***N01***
Location		***Bocabec***	***Maces Bay***	***Welch Cove***	***Lepreau Lighthouse***	***Old Site of Information Centre***	***SRWMF***	***Construction Stores***	***Dipper Harbour***
Distance from PLGS		***45 km***	***4.5 km***	***1.6 km***	***1.0 km***	***0.75 km***	***1.2 km***	***0.55 km***	***3.7 km***
Collection Start Date The sample collection periods are approximately one month in duration. All sample stations are changed at the same time. The start date is the stop date for the previous sample.	2002-01-03	<3.4E-2	1.2E-1	3.0E-1	1.5E+0	1.1E+0	1.5E+0	1.3E+0	1.8E-1
	2002-02-05	1.0E-1	<5.2E-2	3.2E-1	5.3E-1	9.3E-1	1.9E+0	8.6E-1	7.9E-2
	2002-03-12	<6.8E-2	<4.6E-2	2.6E-1	3.5E-1	8.7E-1	1.1E+0	9.9E-1	6.4E-2
	2002-04-10	<7.4E-2	6.9E-2	1.9E-1	7.8E-1	2.1E+0	2.6E+0	1.0E+0	1.7E-1
	2002-05-08	<1.0E-1	<1.0E-1	1.2E-1	1.1E-1	1.6E+0	1.5E+0	5.0E-1	1.9E-1
	2002-06-06	<1.0E-1	<1.3E-1	1.4E+0	5.5E-1	2.5E+0	1.5E+0	2.3E+0	6.2E-1
	2002-07-03	<1.8E-1	1.5E-1	1.8E-1	<2.0E-1	1.9E+0	2.1E+0	9.7E-1	3.2E-1
	2002-07-31	<9.9E-2	8.6E-2	2.1E-1	2.2E-1	1.4E+0	2.7E+0	4.7E-1	3.9E-1
	2002-09-04	<6.3E-2	<6.9E-2	8.2E-2	2.1E-1	9.7E-1	1.6E+0	3.1E-1	3.5E-1
	2002-10-03	<5.9E-2	<8.0E-2	1.6E-1	2.9E-1	4.5E-1	5.0E-1	4.2E-1	8.3E-2
	2002-11-06	<3.4E-2	<1.0E-1	1.0E-1	2.7E-1	6.9E-1	1.2E+0	Data Not Available	4.4E-2
	2002-12-05	<2.3E-2	<3.4E-2	9.6E-2	4.8E-1	4.0E-1	8.4E-1	2.7E-1	<5.0E-2

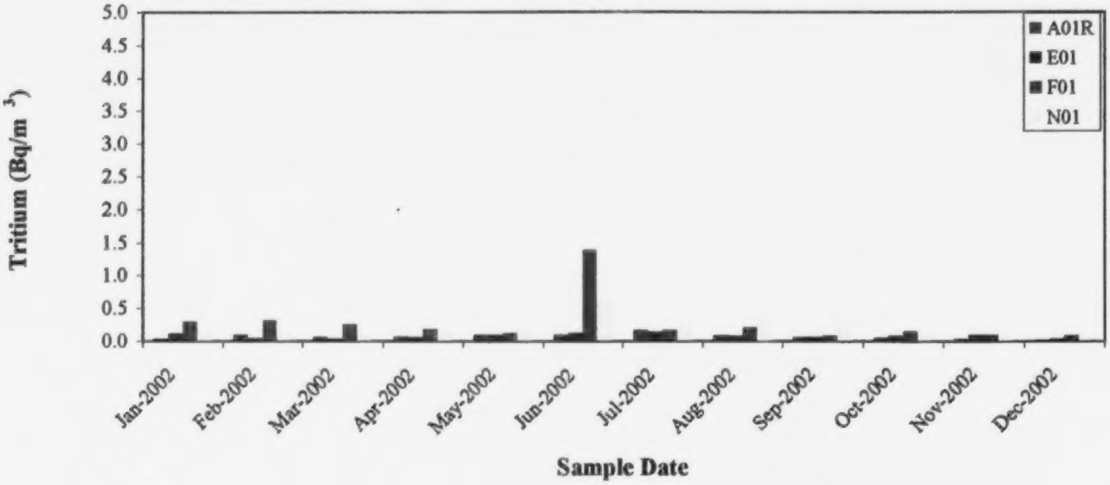

Figure 4.03: Water Vapour (Tritium) for Each Offsite Air Station

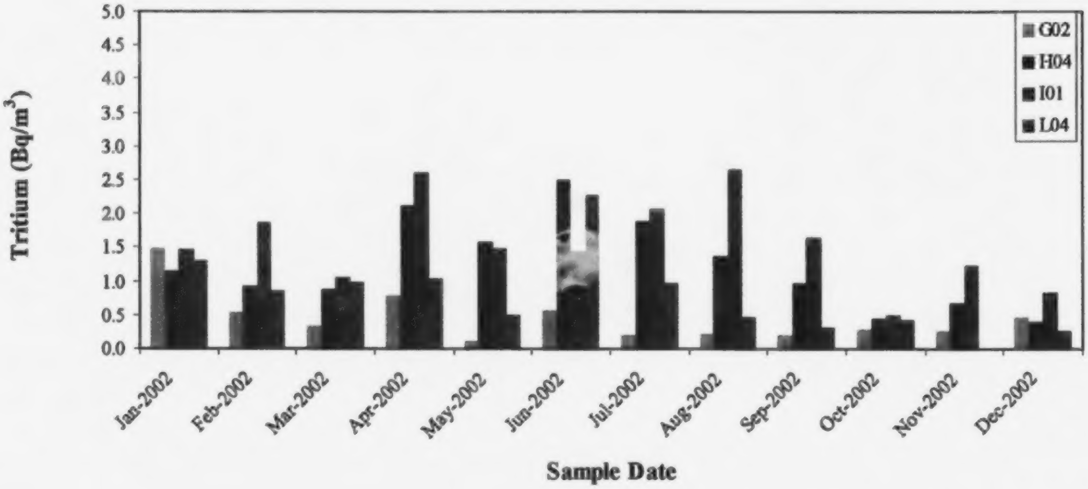

Figure 4.04: Water Vapour (Tritium) for Each Onsite Air Station

4.04 Carbon Dioxide

Carbon-14 was detected in 22 of the 22 samples from the onsite monitors and 10 of the 12 samples from the offsite monitor.

Air is continuously bubbled through a caustic solution at two onsite locations (G02 and H04 in Figure 3.02) and one reference location. The caustic bubblers are changed monthly and returned to the lab for analysis. There was no monitoring at H04 for the period from 2002-07-31 to 2002-10-03 due to equipment failure.

The maximum concentration of C-14 in air onsite was 7.9E-2 Bq/m^3 of air. Offsite it reached 5.5E-2 Bq/m^3. The results for the two onsite monitors (mean of 4.7E-2 Bq/m^3) were very similar to the reference monitor (mean of 4.4E-2 Bq/m^3). Based on stack emissions, the calculated average annual concentration of C-14 in air at the boundary fence for 2002 was approximately 2E-3 Bq/m^3 (well below the natural level of 4E-2 Bq/m^3).

Individual analysis results are given in Table 4.04 by location (graphically shown in Figure 4.05). Table 4.05 gives details of C-14 results.

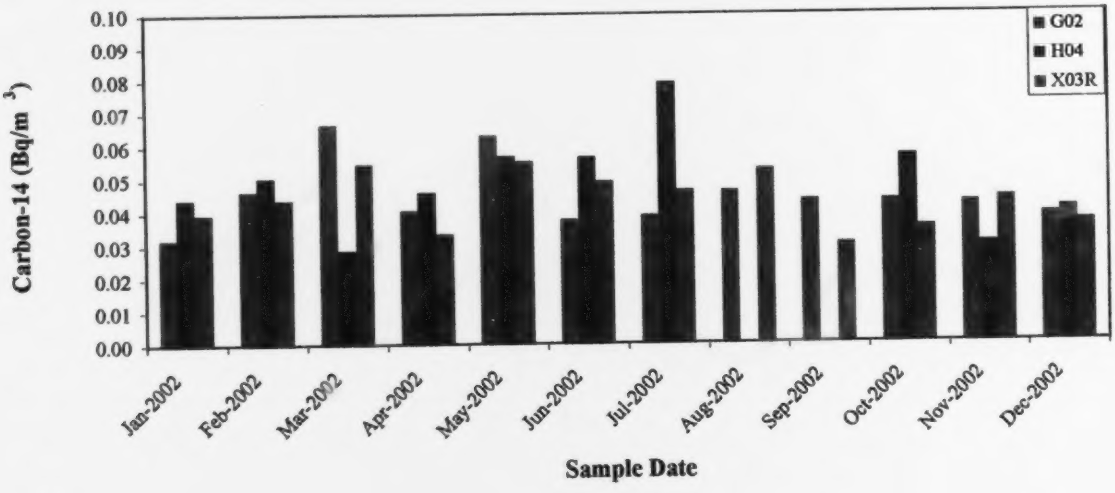

Figure 4.05: Carbon Dioxide (Carbon-14)

Table 4.04: Carbon Dioxide - Carbon-14 (Bq/m^3)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
C-14	34	2.5E-2	1.9E-2 to 4.0E-2	4.7E-2	22/22	2.9E-2 to 7.9E-2	4.4E-2	10/12	3.0E-2 to 5.5E-2

Table 4.05: Carbon Dioxide - Carbon-14 (Bq/m^3)

Location Code		G02	H04	X03R
Location		Lepreau Lighthouse	Old Site of Information Centre	Fredericton Laboratory
Distance from PLGS		1.0 km	0.75 km	100 km
Collection Start Date The sample collection periods are approximately one month in duration. All sample stations are changed at the same time. The start date is the stop date for the previous sample	2002-01-03	3.2E-2	4.4E-2	<4.0E-2
	2002-02-05	4.7E-2	5.1E-2	4.4E-2
	2002-03-12	6.7E-2	2.9E-2	5.5E-2
	2002-04-10	4.1E-2	4.6E-2	3.4E-2
	2002-05-08	6.3E-2	5.7E-2	5.5E-2
	2002-06-06	3.8E-2	5.7E-2	4.9E-2
	2002-07-03	3.9E-2	7.9E-2	4.6E-2
	2002-07-31	4.6E-2	Data Not Available	5.3E-2
	2002-09-04	4.4E-2	Data Not Available	3.0E-2
	2002-10-03	4.4E-2	5.7E-2	3.6E-2
	2002-11-06	4.3E-2	3.0E-2	<4.4E-2
	2002-12-05	3.9E-2	4.1E-2	3.7E- 2

4.05 Ambient Gamma (TLD)

Gamma exposure measurements were slightly higher onsite, especially near the SRWMF and reactor building, than they were offsite.

Ambient gamma radiation is measured by thermoluminescent dosimeters (TLDs) at the 78 locations shown in Figure 3.04. Forty-one of these are near the Solid Radioactive Waste Management Facility. TLDs are changed quarterly. Results on four of the 312 dosimeters placed in the environment were not available (lost due to heavy snow cover).

The average for the SRWMF (890 μGy) is slightly higher than other onsite locations (770 μGy) and boundary locations (620 μGy). These other onsite locations are not significantly different from offsite locations (610 μGy) and the reference location (630 μGy). A new location was added in 2001 in a community remote from PLGS. The area is noted for its natural uranium content. The measurement there (1460 μGy) is higher than any location at PLGS.

Data are given in Table 4.06. The locations J70 and M02, close to the reactor building and the air emissions stack, show increases in gamma radiation due to chronic releases of low levels of noble gases. Increases at the SRWMF locations (I11A to I11L on the perimeter fence of the SRWMF-Phase 1 and I21A to I21L on the perimeter of the SRWMF-Phase 2) are due to low-level waste and used fuel emplacement, and not to station emissions. There is a small, but undefinable, component of radiation on the TLDs at the SRWMF that is due to enhanced natural radiation from the aggregate in the concrete structures. The results for the drop-off TLDs for SRWMF-Phase 2 are shown in Table 4.32. Figure 4.06 compares the reference location results with the results for other locations.

Ten sampling locations were discontinued at the end of 2001. The discontinued locations were near the SRWMF. They were below the line of site to the SRWMF and were hazardous to access.

Table 4.06: Ambient Gamma – TLD (µGy)

Location	*Dose (µGy ± 10%)*				
	1st Quarter	*2nd Quarter*	*3rd Quarter*	*4th Quarter*	*Year*
A01R	129 ± 13	163 ± 16	158 ± 16	179 ± 18	**630 ± 30**
B03	142 ± 14	171 ± 17	172 ± 17	196 ± 20	**680 ± 30**
C03	128 ± 13	153 ± 15	142 ± 14	166 ± 17	**590 ± 30**
D02	159 ± 16	197 ± 20	202 ± 20	211 ± 21	**770 ± 40**
E01	137 ± 14	162 ± 16	158 ± 16	148 ± 15	**600 ± 30**
E04	94 ± 9	119 ± 12	96 ± 10	137 ± 14	**450 ± 20**
E05	146 ± 15	166 ± 17	162 ± 16	NA	**630 ± 30**
E06	188 ± 19	216 ± 22	173 ± 17	200 ± 20	**780 ± 40**
F01	115 ± 12	136 ± 14	143 ± 14	148 ± 15	**540 ± 30**
G02	183 ± 18	201 ± 20	169 ± 17	208 ± 21	**760 ± 40**
H04	144 ± 14	164 ± 16	160 ± 16	185 ± 18	**650 ± 30**
H05	119± 12	138 ± 14	134 ± 13	135 ± 13	**530 ± 30**
I11A	211 ± 21	236 ± 24	219 ± 22	237 ± 24	**900 ± 50**
I11B	223 ± 22	244 ± 24	233 ± 23	246 ± 25	**950 ± 50**
I11C	214 ± 21	240 ± 24	215 ± 21	250 ± 25	**920 ± 50**
I11D	208 ± 21	234 ± 23	225 ± 23	238 ± 24	**900 ± 50**
I11E	208 ± 21	234 ± 23	225 ± 23	236 ± 24	**900 ± 50**
I11F	213 ± 21	232 ± 23	223 ± 22	226 ± 23	**890 ± 40**
I11G	214 ± 21	223 ± 22	256 ± 26	239 ± 24	**930 ± 50**
I11H	221 ± 22	264 ± 26	281 ± 28	228 ± 23	**990 ± 50**
I11I	207 ± 21	233 ± 23	231 ± 23	237 ± 24	**910 ± 50**
I11J	196 ± 20	232 ± 23	244 ± 24	262 ± 26	**930 ± 50**
I11K	211 ± 21	247 ± 25	216 ± 22	234 ± 23	**910 ± 50**
I11L	204 ± 20	228 ± 23	207 ± 21	239 ± 24	**880 ± 40**
I21A	188 ± 19	201 ± 20	191 ± 19	NA	**770 ± 30**
I21B	173 ± 17	194 ± 19	195 ± 20	256 ± 26	**820 ± 40**
I21C	168 ± 17	196 ± 20	191 ± 19	255 ± 25	**810 ± 40**
I21D	343 ± 34	353 ± 35	307 ± 31	NA	**1340 ± 60**
I21E	307 ± 31	318 ± 32	299 ± 30	314 ± 31	**1240 ± 60**
I21F	196 ± 20	213 ± 21	187 ± 19	219 ± 22	**810 ± 40**
I21G	167 ± 17	179 ± 18	161 ± 16	199 ± 20	**710 ± 40**
I21H	179 ± 18	201 ± 20	183 ± 18	207 ± 21	**770 ± 40**
I21I	173 ± 17	196 ± 20	164 ± 16	198 ± 20	**730 ± 40**
I21J	194 ± 19	200 ± 20	178 ± 18	212 ± 21	**780 ± 40**
I21K	188 ± 19	208 ± 21	183 ± 18	NA	**770 ± 30**
I21L	174 ± 17	195 ± 20	181 ± 18	204 ± 20	**750 ± 40**

Table 4.06 (continued): Ambient Gamma – TLD (µGy)

Location	***Dose (µGy ± 10%)***				
	1st Quarter	***2nd Quarter***	***3rd Quarter***	***4th Quarter***	***Year***
I75	181 ± 18	192 ± 19	187 ± 19	187 ± 19	**750 ± 40**
I86	153 ± 15	177 ± 18	162 ± 16	166 ± 17	**660 ± 30**
I87	143 ± 14	171 ± 17	166 ± 17	163 ± 16	**640 ± 30**
I88	159 ± 16	187 ± 19	174 ± 17	172 ± 17	**690 ± 30**
I89	164 ± 16	189 ± 19	160 ± 16	172 ± 17	**680 ± 30**
I90	suspended at the end of 2001				
I91	suspended at the end of 2001				
I92	suspended at the end of 2001				
I93	suspended at the end of 2001				
I94	suspended at the end of 2001				
I95	suspended at the end of 2001				
I98	suspended at the end of 2001				
I99	suspended at the end of 2001				
J00	166 ± 17	190 ± 19	171 ± 17	166 ± 17	**690 ± 30**
J20	180 ± 18	193 ± 19	182 ± 18	199 ± 20	**750 ± 40**
J35	182 ± 18	206 ± 21	179 ± 18	203 ± 20	**770 ± 40**
J70	297 ± 30	229 ± 23	306 ± 31	317 ± 32	**1150 ± 60**
K01	170 ± 17	202 ± 20	182 ± 18	189 ± 19	**740 ± 40**
K02	170 ± 17	201 ± 20	182 ± 18	229 ± 23	**780 ± 40**
L01	155 ± 15	189 ± 19	163 ± 16	154 ± 15	**660 ± 30**
L02	200 ± 20	223 ± 22	230 ± 23	219 ± 22	**870 ± 40**
L03	127 ± 13	140 ± 14	127 ± 13	148 ± 15	**540 ± 30**
L04	180 ± 18	190 ± 19	190 ± 19	183 ± 18	**740 ± 40**
M02	248 ± 25	279 ± 28	248 ± 25	255 ± 26	**1030 ± 50**
N01	148 ± 15	175 ± 18	155 ± 15	186 ± 19	**660 ± 30**
P01	102 ± 10	129 ± 13	109 ± 11	118 ± 12	**460 ± 20**
P03	118 ± 12	157 ± 16	145 ± 14	137 ± 14	**560 ± 30**
X12	361 ± 36	380 ± 38	350 ± 35	374 ± 37	**1460 ± 70**
YTL1	133 ± 13	147 ± 15	120 ± 12	178 ± 18	**580 ± 30**
YTL2	129 ± 13	147 ± 15	129 ± 13	169 ± 17	**570 ± 30**
YTL3	98 ± 10	107 ± 11	92 ± 9	147 ± 15	**440 ± 20**
YTL4	100 ± 10	103 ± 10	87 ± 9	147 ± 15	**440 ± 20**
YTL5	164 ± 16	174 ± 17	152 ± 15	201 ± 20	**690 ± 30**

NA :Data Not Available – Lost or destroyed TLD for this collection interval.

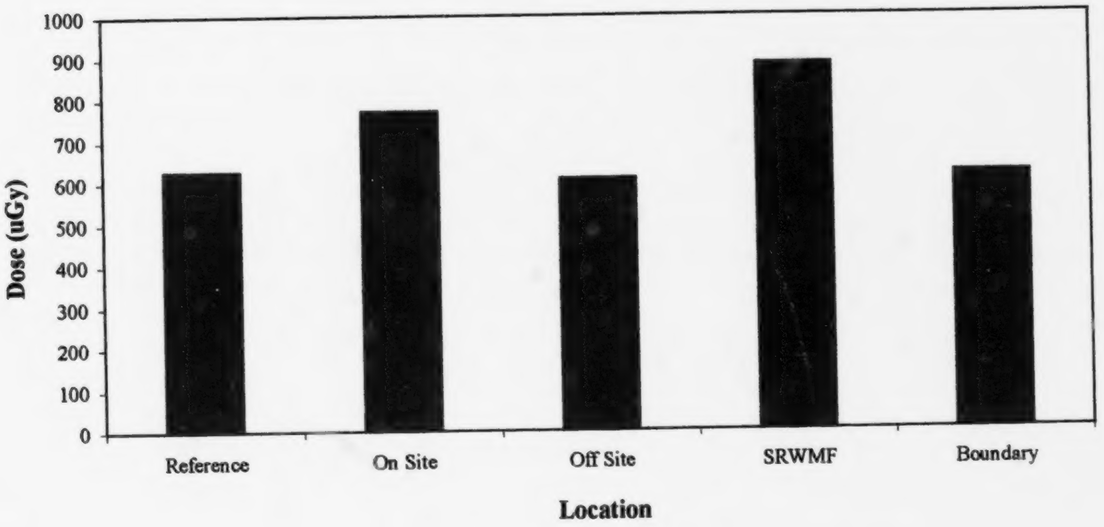

Figure 4.06: Mean TLD Results

4.06 Milk

There were no detectable radionuclides that could be attributed to the operation of PLGS in any of the 25 samples analysed.

There are no commercial herds or individual cows producing milk in the Point Lepreau area. The closest herds to PLGS are in Oak Bay (60 km distant), Fredericton Junction (70 km distant), and Hammond River (60 km distant), and the milk from these locations is analysed quarterly. Milk from a commercial dairy is purchased each month from a supermarket in Fredericton. All samples are analysed for gamma emitting radionuclides and tritium.

Tritium was detected in one of the 25 samples collected (13 Bq/L). This was very near the Critical Level of 12 Bq/L and is believed to be a statistical "false positive". Cesium-137 was detected in one sample (0.07 Bq/L). The Cs-137 originated from fallout of bomb tests and the Chernobyl accident, and concentrations have been declining ever since. Milk samples analysed between 1977 and 1982, before PLGS began operations, contained an average of 1.2 Bq/L of Cs-137. The cow preferentially absorbs cesium if there is a dietary deficiency in potassium. Naturally occurring K-40 (average of 50 Bq/L) was also detected in milk. As airborne emissions from PLGS are monitored continuously, and were insignificant all year, neither tritium nor gamma emitting radionuclides attributable to the operation of PLGS would be expected to be detected in these milk samples.

Table 4.07 is a summary of the detected radionuclides in milk.

Table 4.07: Milk (Bq/L)

Analysis Type	***Total Number***	***Critical Level***		***Indicator Stations***			***Reference Station***		
		Mean	***Range***	***Mean***	***Frequency***	***Range***	***Mean***	***Frequency***	***Range***
H-3	25	1.2E+1	1.0E+1 to 1.3E+1	*	0/13	*	1.3E+1	1/12	1.3E+1 to 1.3E+1
Cs-137	24	4.9E-2	3.9E-2 to 5.7E-2	7.0E-2	1/12	7.0E-2 to 7.0E-2	*	0/12	*
K-40	24	1.7E+0	7.8E-2 to 3.5E+0	5.0E+1	12/12	4.6E+1 to 5.3E+1	5.0E+1	12/12	4.7E+1 to 5.3E+1

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.07 Airborne Strontiums (GEM)

Since Sr-89,90 emissions are so low, the expected concentration in environmental samples is well below the detection limit.

The Gaseous Effluent Monitor (GEM) monitors PLGS gaseous emissions continuously at their source. The filters are changed daily and the weekly composite is sent to the lab for analysis. Fifty-two sets of these filters were analysed for Sr-89,90. If the release rate warrants, or if significant beta activity is detected in environmental air samples, a Sr-89,90 analysis is performed on those samples.

Strontium-90 was detected on two of these filter sets at a level close to the detection limit. This translated into 1.0E+04 Bq released in 2002, compared with an annual DEL of 1.2E+13. No further analyses were required. See Figure 4.07.

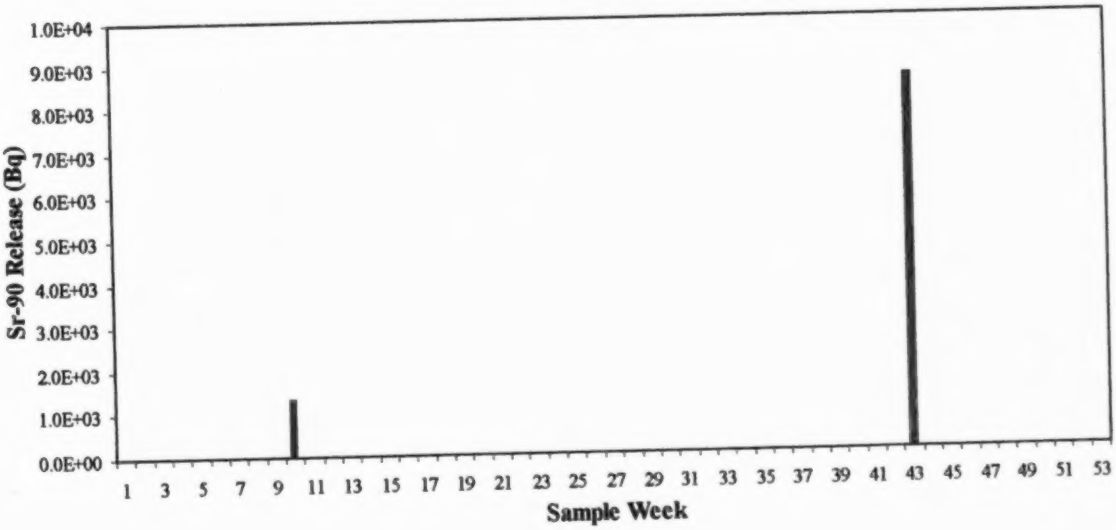

Figure 4.07: Sr-90 Releases (measured at source)

4.08 Well Water

No gamma emitting radionuclides were detected in any of the 31 samples. Alpha and beta activity were detected in all the samples, and H-3 was detected in 19 samples.

Water is collected semi-annually from the 11 wells shown in Figure 3.03. Two of these wells are onsite. The first sample of the year was not collected from D03 due to a scheduling error.
Ten additional wells are sampled once per year. These are located just outside the exclusion boundary and belong to local residents.

The alpha (up to 0.2 Bq/L) and beta (up to 0.1 Bq/L) activity is due to the presence of naturally occurring radionuclides peculiar to certain locations. Detected H-3 activity ranged from 12 to 43 Bq/L. Tritium from PLGS emissions washes out into precipitation and subsequently drains into some of the wells. Rainwater analyses (Section 4.14) indicate H-3 concentrations ranging from 15 to 1100 Bq/L in 44 of 49 samples.

Table 4.08 is a summary of the detected radionuclides in well water. Figures 4.08 and 4.09 show the gross beta and H-3 results for each sample. “Less Than” values are plotted for non-detected results. The H-3 measurements were made after samples had been allowed to sit for up to two weeks to reduce radioactive interference from the relatively abundant, but short half-life, radon progeny which are common in most well waters.

The 1996 *Guidelines for Canadian Drinking Water Quality* recommends 7000 Bq/L as the maximum acceptable concentration for H-3 in drinking water. The highest average well water H-3 content was less than one percent of the recommended maximum concentration.

Table 4.08: Well Water (Bq/L)

Analysis Type	***Total Number***	***Critical Level***		***Indicator Stations***			***Reference Station***		
		Mean	***Range***	***Mean***	***Frequency***	***Range***	***Mean***	***Frequency***	***Range***
Alpha	31	8.5E-2	4.4E-2 to 2.0E-1	2.5E-1	13/29	8.6E-2 to 7.4E-1	6.7E-2	2/2	4.9E-2 to 8.4E-2
Beta	31	4.2E-2	2.1E-2 to 9.9E-2	1.2E-1	27/29	3.1E-2 to 4.8E-1	8.9E-2	2/2	8.4E-2 to 9.4E-2
H-3	31	1.2E+1	1.1E+1 to 1.4E+1	2.0E+1	19/29	1.2E+1 to 4.3E+1	*	0/2	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

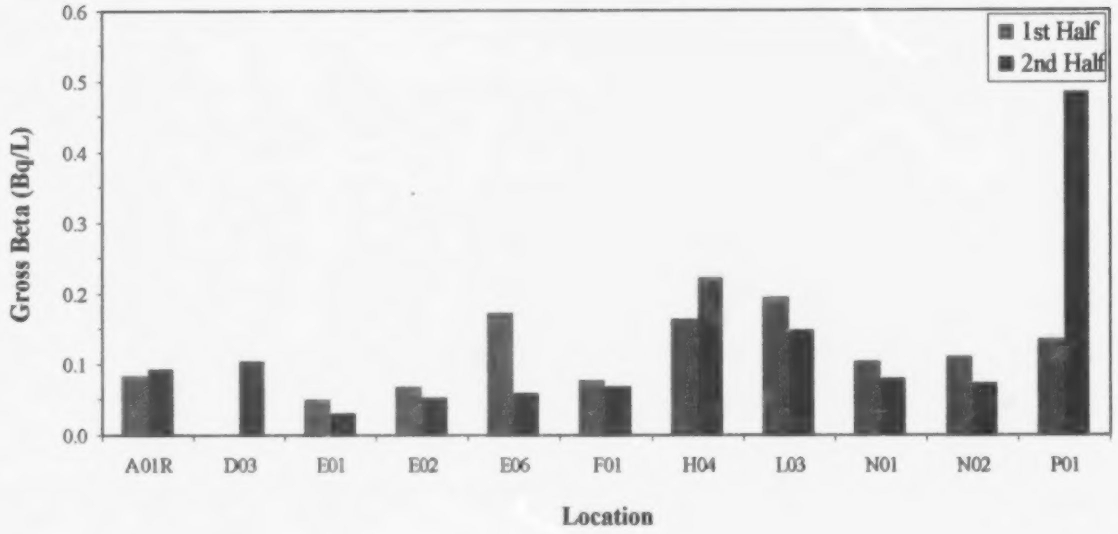

Figure 4.08: Gross Beta in Well Water

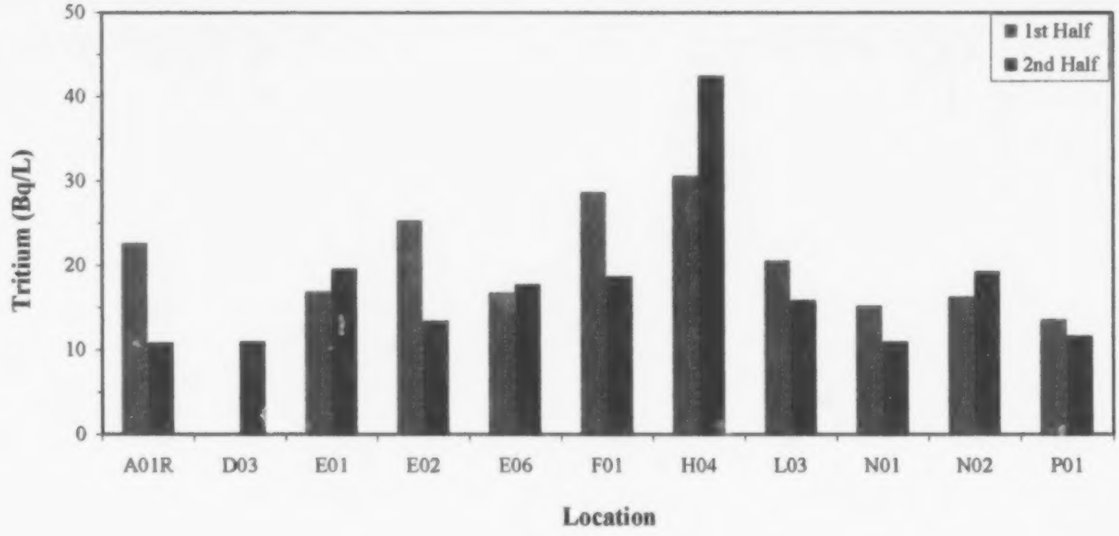

Figure 4.09: Tritium in Well Water

4.09 Pond/Puddle/Surface Water

Tritium was detected in 6 of the 15 samples. No other radionuclides attributable to PLGS emissions were detected.

This category includes ponds, lakes, streams, and runoff samples. Most of these samples are from onsite locations. Two important offsite locations, sampled quarterly, are the freshwater supply reservoirs for Saint John and PLGS.

Detected H-3 activity ranged from 46 to 120 Bq/L. Variability can be due to the size of the reservoir and the residence time at the location. Naturally occurring Be-7 was detected in one sample.

Table 4.09 is a summary of the detected radionuclides in surface water. Figure 4.10 shows H-3 results for each location. "Less Than" values are plotted for non-detected results.

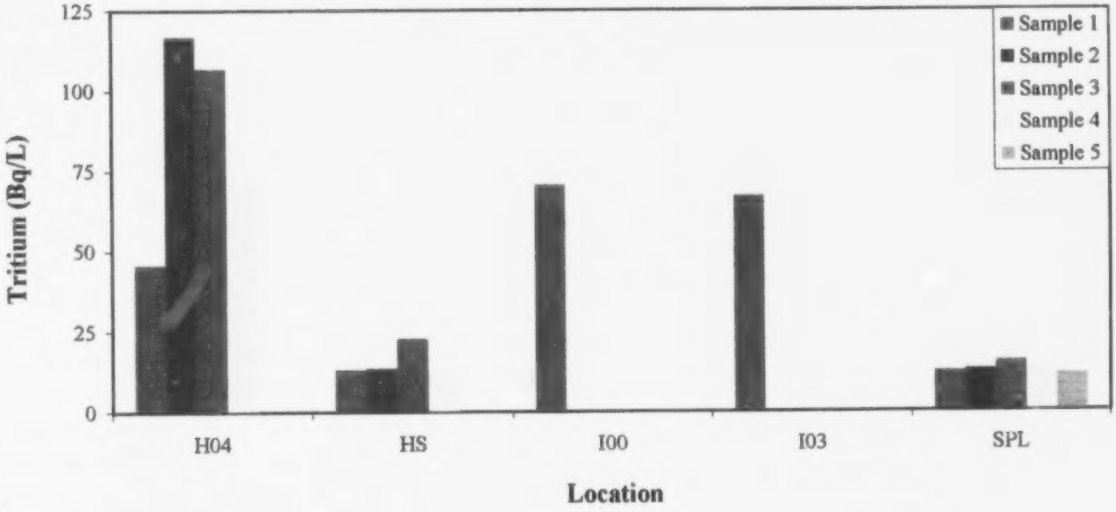

Figure 4.10: Tritium in Pond/Puddle/Surface Water

Table 4.09: Pond/Puddle/Surface Water (Bq/L)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
H-3	15	1.3E+1	1.1E+1 to 1.4E+1	8.0E+1	6/15	4.6E+1 to 1.2E+2	*	*	*
Be-7	15	1.6E+0	9.9E-1 to 3.1E+0	2.1E+0	1/15	2.1E+0 to 2.1E+0	*	*	*

*There is no Reference location for this sample type.

4.10 Berries

No radionuclides attributable to PLGS emissions were detected in these 4 samples.

Berries are sampled weekly when in season. Two of these samples were blueberries from the commercial fields at Pennfield and one from an onsite patch. A sample of raspberries from Dipper Harbour was provided by a local resident.

It is not unusual to detect Cs-137 in berries throughout North America, although none was seen this year. As in many food samples, naturally occurring K-40 was detected in the four samples (32 to 42 Bq/kg).

Table 4.10 is a summary of the detected radionuclides in berries.

4.11 Garden Vegetables

No radionuclides attributable to PLGS emissions were detected in these 17 samples.

All samples were taken from a local garden in Dipper Harbour (4 km away from PLGS in the predominant wind direction). These samples were supplied weekly during the growing season.

As in most food samples, naturally occurring K-40 was detected in 14 samples (64 to 230 Bq/kg).

Table 4.11 is a summary of the detected radionuclides in garden vegetables.

4.12 Vegetation (Lichen)

No radionuclides attributable to PLGS emissions were detected in these 16 samples.

These samples are collected whenever and wherever available from onsite locations.

Different species of lichen and moss concentrate a wide range of radionuclides and are sensitive indicators of radionuclides in the environment. Cosmogenically produced Be-7 was detected in all samples (100 to 290 Bq/kg), naturally occurring K-40 was detected in two samples (180 to 220 Bq/kg) and Cs-137 was detected in two samples (13 to 22 Bq/kg). In past years, lichen from a now abandoned Reference location had Cs-137 concentrations up to 320 Bq/kg (average 65 Bq/kg).

Table 4.12 is a summary of the detected radionuclides in vegetation.

Table 4.10: Berries, Various (Bq/kg)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	***Range***	***Mean***	***Frequency***	***Range***	***Mean***	***Frequency***	***Range***
K-40	4	1.5E+1	5.8E+0 to 3.8E+1	3.8E+1	4/4	3.2E+1 to 4.2E+1	*	*	*

* There is no Reference location for this sample type.

Table 4.11: Garden Vegetables (Bq/kg)

Analysis Type	***Total Number***	***Critical Level***		***Indicator Stations***			***Reference Station***		
		Mean	***Range***	***Mean***	***Frequency***	***Range***	***Mean***	***Frequency***	***Range***
K-40	17	5.0E+1	7.4E+0 to 1.8E+2	1.0E+2	14/17	6.4E+1 to 2.3E+2	*	*	*

* There is no Reference location for this sample type.

Table 4.12: Vegetation (Bq/kg)

Analysis Type	***Total Number***	***Critical Level***		***Indicator Stations***			***Reference Station***		
		Mean	***Range***	***Mean***	***Frequency***	***Range***	***Mean***	***Frequency***	***Range***
Be-7	16	5.7E+1	2.4E+1 to 1.1E+2	1.9E+2	16/16	1.0E+2 to 2.9E+2	*	*	*
Cs-137	16	1.2E+1	5.6E+0 to 2.0E+1	1.8E+1	2/16	1.3E+1 to 2.2E+1	*	*	*
K-40	16	2.0E+2	3.9E+1 to 3.4E+2	2.0E+2	2/16	1.8E+2 to 2.2E+2	*	*	*

* There is no Reference location for this sample type.

4.13 Soil

There were no detectable radionuclides that could be attributed to the operation of PLGS in any of the 38 samples analysed.

Soil samples are taken quarterly from the eight air monitoring location sites shown in Figure 3.02. Two samples from E01 were replaced by samples from nearby locations due to personnel reluctance to disrupt the homeowner's lawn (in the summer).

Most samples contained naturally occurring K-40 (230 to 870 Bq/kg), Be-7 (17 to 130 Bq/kg) and Ac-228 (17 to 80 Bq/kg). Twenty-four contained Cs-137 (2.2 to 120 Bq/kg) at typical levels for the region (see Table 4.13).

Table 4.13 is a summary of the detected radionuclides in soil. Figure 4.11 shows individual Cs-137 results that seem to be a function of the organic load in the sample. "Less Than" values are plotted for non-detected results.

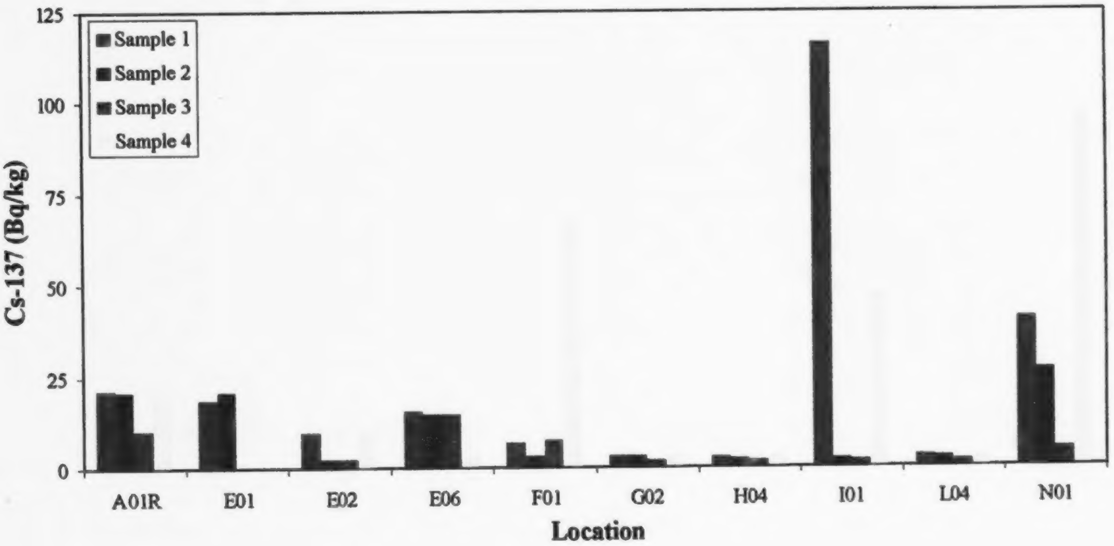

Figure 4.11: Cs-137 in Soil

Table 4.13: Soil (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
Be-7	38	1.6E+1	7.8E+0 to 4.8E+1	5.2E+1	10/34	1.7E+1 to 1.3E+2	3.6E+1	1/4	3.6E+1 to 3.6E+1
Cs-137	38	2.3E+0	7.0E-1 to 1.7E+1	2.7E+1	20/34	2.2E+0 to 1.2E+2	1.8E+1	4/4	1.0E+1 to 2.1E+1
Ac-228	38	4.3E+0	1.5E+0 to 1.9E+1	3.5E+1	30/34	1.7E+1 to 6.2E+1	4.9E+1	4/4	3.1E+1 to 8.0E+1
K-40	38	8.2E+1	5.8E+0 to 1.7E+2	5.8E+2	33/34	2.3E+2 to 8.7E+2	5.7E+2	4/4	4.4E+2 to 7.0E+2

4.14 Rain Water

Tritium from PLGS was detected in 44 of 49 onsite samples.

Rain water is collected continuously at the four onsite air monitoring stations (shown in Figure 3.02). The samples are changed approximately monthly, depending on rainfall and freeze up.

Detected H-3 levels spanned 15 to 1100 Bq/L, depending on the amount of rainfall. Naturally occurring Be-7 was also detected in six of the 49 samples (1.4 to 2.9 Bq/L).

Table 4.14 is a summary of the detected radionuclides in rain water. Figure 4.12 shows individual H-3 results. "Less Than" values are plotted for non-detected results.

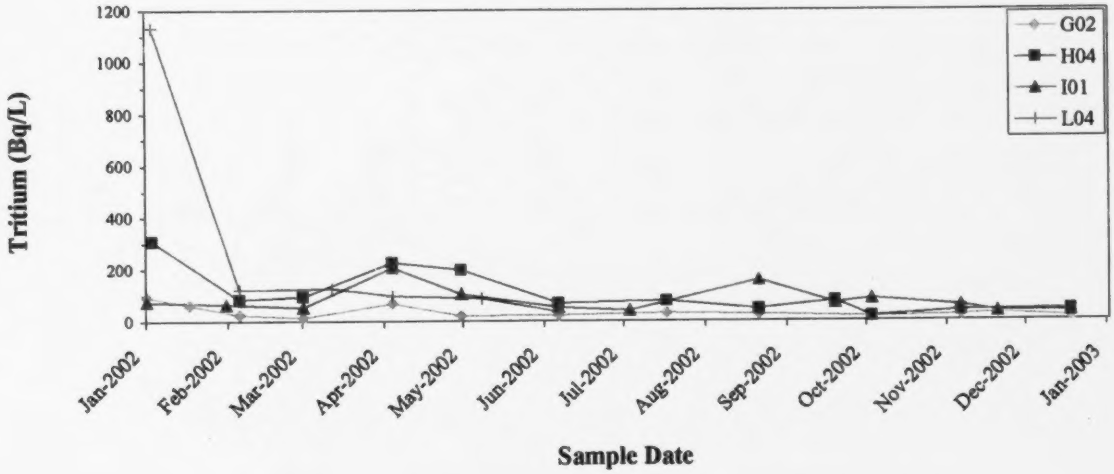

Figure 4.12: Tritium in Rain Water

4.15 Monitoring Well Water (Near Plant)

Tritium from PLGS was detected in all 33 samples analysed. No other radionuclides attributable to the operation of PLGS were detected.

In the summer of 2000, a geotechnical firm evaluated the onsite groundwater movement and made recommendations for an improved monitoring program. Based on their advice, nine new bore holes in and around the SRWMF and eleven new monitoring wells near the plant were drilled, bringing the total to 35. In the fall of 2001, the CNSC inspected these new wells and met with NB Power's hydrogeologists. An enhanced monitoring program was established to give a better understanding of groundwater movement. Each well was sampled three times in 2002. At the same time that the samples were taken, physical data were recorded. At the end of 2002, these data were given to the hydrogeologists for evaluation. A report was issued by the geotechnical firm early in 2003 which confirmed previously expected groundwater movement on the peninsula.

Tritium concentrations averaged 360 Bq/L, ranging up to 1300 Bq/L. The highest concentrations are found close to the stack at locations J02A and J02B. Tritium levels in the groundwater are decreasing, or are currently at a level below regulatory concern. The impact from current levels on humans and the environment is negligible.

Table 4.15 is a summary of the detected radionuclides in monitoring well water. Figure 4.13 shows individual H-3 results. "Less Than" values are plotted for non-detected results.

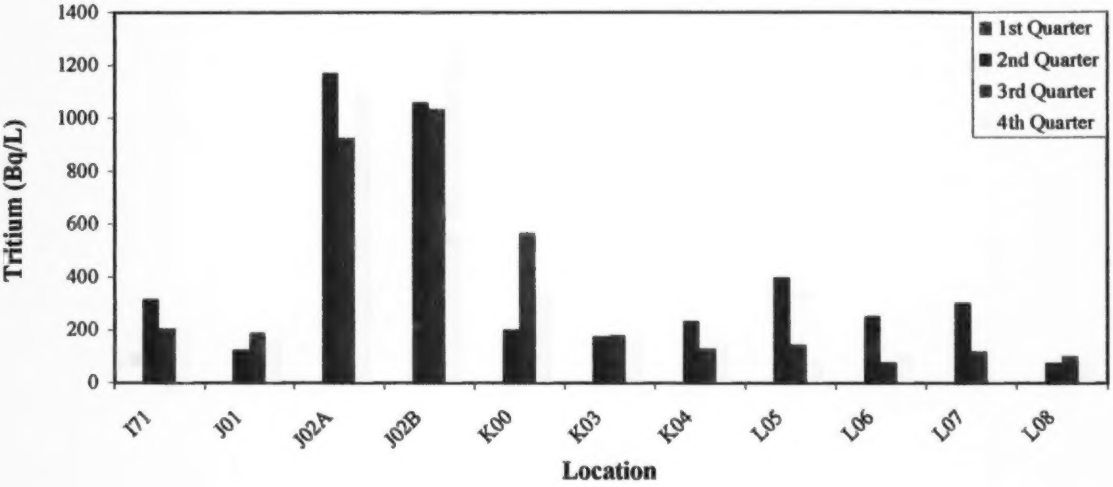

Figure 4.13: Tritium in Monitoring Well Water

4.16 Seawater

Tritium from PLGS was detected in two of the 16 samples analysed. No other radionuclides attributable to the operation of PLGS were detected.

Seawater is collected quarterly from three locations close to PLGS and one reference location near Saint John (shown in Figure 3.05).

Natural K-40 was detected (4.9 to 14 Bq/L) in all 16 samples. The two detected H-3 (12 and 17 Bq/L) were very close to the Critical Level. Calculations suggest that the long term average concentration of tritium in seawater due to releases from PLGS in the liquid pathway would be about 70 Bq/L at the out-fall (samples are not usually collected at this point, but are taken at the shoreline nearby). This calculation takes into account the total tritium released over the year, the flow rate of the condenser cooling water (about 24 m^3/s), and tidal mixing. A dilution factor of 20 is assumed for tidal mixing at the out-fall during normal coolant flows. For collection further away, a tidal mixing factor of about 40, or even higher, is more realistic. A factor of 40 would result in an average H-3 concentration of about 11 Bq/L of seawater in 2002 at the H03 location.

Table 4.16 is a summary of the detected radionuclides in seawater.

Table 4.14: Rain Water (Bq/L)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
H-3	49	1.2E+1	1.1E+1 to 1.3E+1	1.0E+2	44/49	1.5E+1 to 1.1E+3	*	*	*
Be-7	49	3.2E+0	8.1E-1 to 6.0E+0	2.3E+0	6/49	1.4E+0 to 2.9E+0	*	*	*

* There is no Reference location for this sample type.

Table 4.15: Monitoring Well Water – Near Plant (Bq/L)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
H-3	33	1.2E+1	1.1E+1 to 1.5E+1	3.6E+2	33/33	1.5E+1 to 1.3E+3	*	*	*

* There is no Reference location for this sample type.

Table 4.16: Seawater (Bq/L)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
H-3	16	1.3E+1	1.1E+1 to 1.4E+1	1.4E+1	2/12	1.2E+1 to 1.7E+1	*	0/4	*
K-40	16	3.7E+0	7.9E-1 to 6.2E+0	1.1E+1	12/12	6.8E+0 to 1.4E+1	9.1E+0	4/4	4.9E+0 to 1.1E+1

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.17 Clams

No radionuclides attributable to PLGS emissions were detected in the 10 samples analysed.

These samples are collected whenever and wherever available from the area. The nature of the fishery has changed over the last few years. The inshore fishery often faces restrictions placed upon the harvesting of shellfish, either for conservation of stocks or because of bacterial contamination, algal blooms, or other natural cycles. This restricts the availability of these sample types for analysis. Sample locations are shown in Figure 3.05.

Naturally occurring K-40 was detected in nine samples (84 to 280 Bq/kg). See Table 4.17.

4.18 Fish

No samples were available for analysis in 2002. The nature of the fishery has changed since the 1980s. Herring and mackerel, which used to make up the bulk of the analyses, are now less available for analysis. The fish category now tends to be made up of dogfish, cod, hake and sardines, if they are available at all.

4.19 Lobster

No radionuclides attributable to PLGS emissions were detected in the 6 samples analysed.

Several of the samples were collected close to the cooling water outflow from PLGS. Sample locations are shown in Figure 3.05. Several lobster are obtained during each of the two federally regulated fishing seasons per year.

Naturally occurring K-40 was detected in six samples (67 to 100 Bq/kg). See Table 4.18.

4.20 Periwinkles

No radionuclides attributable to PLGS emissions were detected in the 12 samples analysed.

Naturally occurring K-40 was detected in ten samples (79 to 200 Bq/kg). See Table 4.19. Sample locations are shown in Figure 3.05.

4.21 Aquaculture Salmon

No radionuclides attributable to PLGS emissions were detected in the 2 samples analysed.

The aquaculture salmon industry is important to the area west of PLGS. Both samples were from the new site in Welch Cove. Naturally occurring K-40 was detected in both samples (110 to 160 Bq/kg). See Table 4.20.

Table 4.17: Clams, Edible, Raw Mass (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
K-40	10	6.4E+1	1.6E+1 to 1.7E+2	1.7E+2	9/10	8.4E+1 to 2.8E+2	*	*	*

* There is no Reference location for this sample type.

Table 4.18: Lobster, Edible, Cooked Mass (Bq/kg)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
K-40	6	2.7E+1	8.9E+0 to 5.7E+1	7.9E+1	6/6	6.7E+1 to 1.0E+2	*	*	*

* There is no Reference location for this sample type.

Table 4.19: Periwinkles, Edible, Raw Mass (Bq/kg)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
K-40	12	5.2E+1	1.7E+1 to 1.1E+2	1.3E+2	10/12	7.9E+1 to 2.0E+2	*	*	*

* There is no Reference location for this sample type.

Table 4.20: Aquaculture Salmon, Raw Mass (Bq/kg)

Analysis Type	***Total Number***	***Critical Level***		***Indicator Stations***			***Reference Station***		
		Mean	***Range***	***Mean***	***Frequency***	***Range***	***Mean***	***Frequency***	***Range***
K-40	2	2.6E+1	2.1E+1 to 3.2E+1	1.4E+2	2/2	1.1E+2 to 1.6E+2	*	*	*

* There is no Reference location for this sample type.

4.22 Scallops

No radionuclides attributable to PLGS emissions were detected in the sample analysed.

The inshore fishery often faces restrictions or total bans placed upon the harvesting of scallops for conservation of stocks. This affects the number of samples available for analysis. Samples are obtained from Maces Bay or areas distant from the plant.

Naturally occurring K-40 was detected in this sample (180 Bq/kg). See Table 4.21.

4.23 Crab

No radionuclides attributable to PLGS emissions were detected in the sample analysed.

Most years, there is no active crab fishery in the local area. Only one sample was available for analysis in 2002.

Naturally occurring K-40 was detected in this sample (1300 Bq/kg). See Table 4.22.

4.24 Dulse

No radionuclides attributable to PLGS emissions were detected in the eight samples analysed.

Dulse is an edible seaweed that is a popular snack food in the area. Sample locations are shown in Figure 3.05.

Naturally occurring K-40 was detected in eight samples (300 to 530 Bq/kg). See Table 4.23.

4.25 Other Sea Plants

No radionuclides attributable to PLGS emissions were detected in the 12 samples analysed.

Sea plants other than dulse are analysed. Various species of seaweed (for example, *Ascophylum*) occur on the rocks on the Point Lepreau peninsula and are collected from time to time. Sample locations are shown in Figure 3.05.

Cosmogenically produced Be-7 was detected in four samples (5.2 to 17 Bq/kg). All contained naturally occurring K-40 (140 to 390 Bq/kg). See Table 4.24.

Table 4.21: Scallops, Edible, Raw Mass (Bq/kg)

Analysis Type	***Total Number***	***Critical Level***		***Indicator Stations***			***Reference Station***		
		Mean	***Range***	***Mean***	***Frequency***	***Range***	***Mean***	***Frequency***	***Range***
K-40	1	6.0E+1	6.0 E+1 to 6.0E+1	1.8E+2	1/1	1.8E+2 to 1.8E+2	*	*	*

* There is no Reference location for this sample type.

Table 4.22: Crab, Edible, Cooked Mass (Bq/kg)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
K-40	1	2.0E+2	2.0 E+2 to 2.0E+2	1.3E+3	1/1	1.3E+3 to 1.3E+3	*	*	*

* There is no Reference location for this sample type.

Table 4.23: Dulse, Wet Mass (Bq/kg)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
K-40	8	9.0E+1	1.1E+1 to 1.4E+2	4.0E+2	8/8	3.0E+2 to 5.3E+2	*	*	*

* There is no Reference location for this sampletype.

Table 4.24: Sea Plants Wet Mass (Bq/kg)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
Be-7	12	6.9E+0	2.6E+0 to 1.1E+1	1.0E+1	4/12	5.2E+0 to 1.7E+1	*	*	*
K-40	12	5.1E+1	3.7E+1 to 6.9E+1	2.5E+2	12/12	1.4E+2 to 3.9E+2	*	*	*

* There is no Reference location for this sample type.

4.26 Sediment

There were no detectable radionuclides that could be attributed to the operation of PLGS in any of the 39 samples analysed.

Sediments are collected quarterly from ten locations shown in Figure 3.05. One sample from Q01R was not collected due to the timing of the tides.

All samples contained K-40 (370 to 710 Bq/kg) from the natural potassium in feldspar, a common mineral. Most samples contained cosmogenically produced Be-7 (9.5 to 75 Bq/kg) and Ac-228 (8.2 to 54 Bq/kg), a radioactive progeny of naturally occurring Th-232. Six contained Cs-137 (1.7 to 3.5 Bq/kg) from the diminishing levels of Cs-137 fallout from bomb tests since the 1950s. Sediment samples analysed between 1977 and 1982, before PLGS began operations, contained an average of 5.0 Bq/kg of Cs-137. A small additional Cs-137 component from Chernobyl was added to this reservoir in 1986. Finer grain sediments have a higher radioactivity content than coarse sediments.

Table 4.25 is a summary of the detected radionuclides in sediment. Figure 4.14 shows individual Cs-137 results. "Less Than" values are plotted for non-detected results.

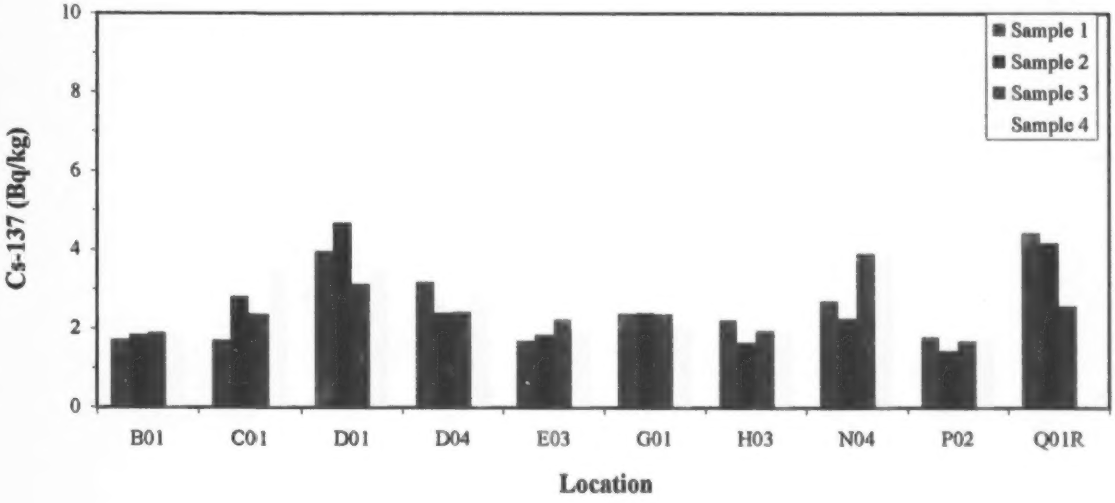

Figure 4.14: Cs-137 in Sediment

Table 4.25: Sediment (Bq/kg)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
Be-7	39	9.4E+0	4.5E+0 to 1.4E+1	2.8E+1	21/36	9.5E+0 to 7.5E+1	5.2E+1	3/3	4.6E+1 to 5.9E+1
Cs-137	39	1.2E+0	7.2E-1 to 2.3E+0	2.6E+0	5/36	1.7E+0 to 3.5E+0	2.6E+0	1/3	2.6E+0 to 2.6E+0
Ac-228	39	2.9E+0	1.4E-0 to 5.1E+0	2.2E+1	32/36	8.2E+0 to 4.2E+1	3.7E+1	3/3	2.6E+1 to 5.4E+1
K-40	39	7.9E+1	8.9E+0 to 1.2E+2	5.2E+2	36/36	3.7E+2 to 7.1E+2	6.3E+2	3/3	6.1E+2 to 6.8E+2

4.27 Gamma Surveys (Beaches)

Environmental gamma survey measurements are made in the inter-tidal zone on beaches in the Point Lepreau area and at the reference location 28 km to the east-northeast (Figure 3.05). Although TLDs are preferred in measuring such exposures since they span the entire year and provide integrated measurements, they cannot be used in these locations. Radiation values measured in 2002 were consistent with those measured prior to station start-up in 1982. These are summarised in Table 4.26. One sample from Q01R was not collected due to the timing of the tides.

Table 4.26: Beach Surveys - Inter-tidal Zone - Ion Chamber (μSv/h)

Location	*1st Quarter**	*2nd Quarter**	*3rd Quarter**	*4th Quarter**
B01	0.20	0.23	0.21	0.20
C01	0.14	0.17	0.20	0.23
D01	0.18	0.12	0.20	0.16
D04	0.18	0.11	0.20	0.19
E03	0.13	0.17	0.19	0.19
G01	0.20	0.18	0.18	0.18
H03	0.25	0.19	0.25	0.21
N04	0.19	0.17	0.18	0.20
P02	0.13	0.17	0.13	0.16
Q01R	NA	0.19	0.18	0.22

NA :Data Not Available

*Although two decimal places are quoted, none of the determinations has this degree of precision nor of accuracy. The data are quoted to two figures just as they are estimated from the low level gamma meter at each location. They should be regarded as about 0.1 to 0.2 μSv/h.

4.28 Liquid Strontiums (LEM)

Since Sr-89,90 releases are so low, the expected concentration in environmental samples is well below the detection limit.

The Liquid Effluent Monitor (LEM) collects samples of PLGS liquid emissions. A monthly composite is sent to the lab for analyses. Twelve of these composites were analysed for Sr-89,90. If the release rate warrants, a Sr-89,90 analysis is performed on seawater samples.

Strontium-89 was detected in one of these LEM samples at a level close to the detection limit. This translated into 1.2E+05 Bq released, compared with an annual DEL of 4.4E+16 Bq. Strontium-90 was detected in each of these LEM samples at a level close to the detection limit. This translated into 2.3E+06 Bq released, compared with an annual DEL of 2.2E+15 Bq. No further analyses were required. See Figure 4.15.

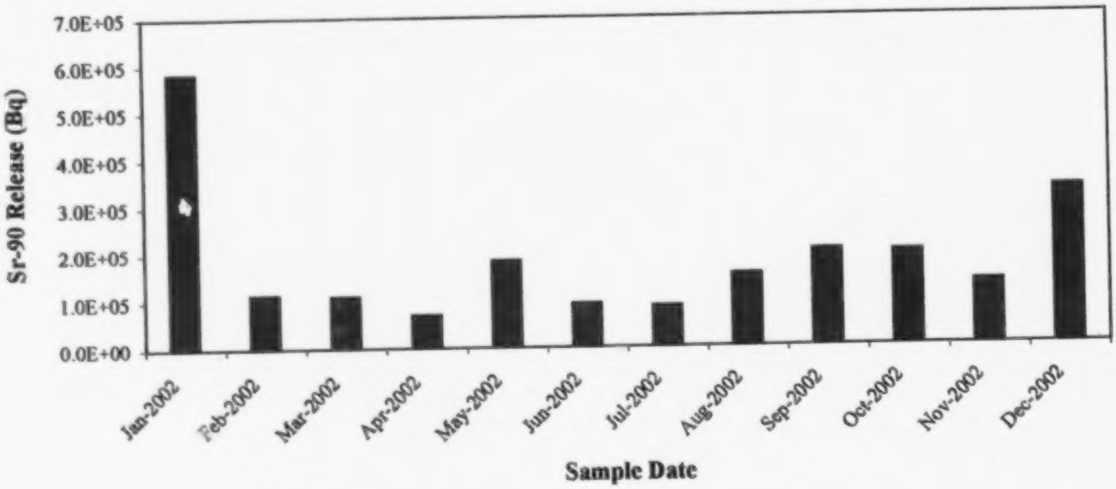

Figure 4.15: Sr-90 Releases (measured at source)

4.29 Bore Hole Water (SRWMF)

Tritium from PLGS was detected in all 67 samples analysed. No other radionuclides attributable to the operation of PLGS were detected.

In the summer of 2000, a geotechnical firm evaluated the onsite groundwater movement and made recommendations for an improved monitoring program. Based on their advice, nine new bore holes in and around the SRWMF and eleven new monitoring wells near the plant were drilled, bringing the total to 35. In the fall of 2001, the CNSC inspected these new wells and met with NB Power's hydrogeologists. An enhanced monitoring program was established to give a better understanding of groundwater movement. Each well was sampled three times in 2002. At the same time that the samples were taken, physical data were recorded. At the end of 2002, these data were given to the hydrogeologists for evaluation. A report was issued by the geotechnical firm early in 2003 which confirmed previously expected groundwater movement on the peninsula.

Tritium concentrations averaged 79 Bq/L, ranging up to 280 Bq/L. Tritium originates in the washout into precipitation and subsequent drainage into some of the bore holes. Rainwater analyses indicate H-3 concentrations ranging from 15 to 1100 Bq/L in 44 of 49 samples (Section 4.14). See Tables 4.27 and 4.28. Figure 4.16 shows the H-3 activity at each bore hole for each sample. Locations I10A-I10E are the closest to the SRWMF- Phase 1 structures and may be affected by the higher H-3 levels associated with them. "Less Than" values are plotted for non-detected results.

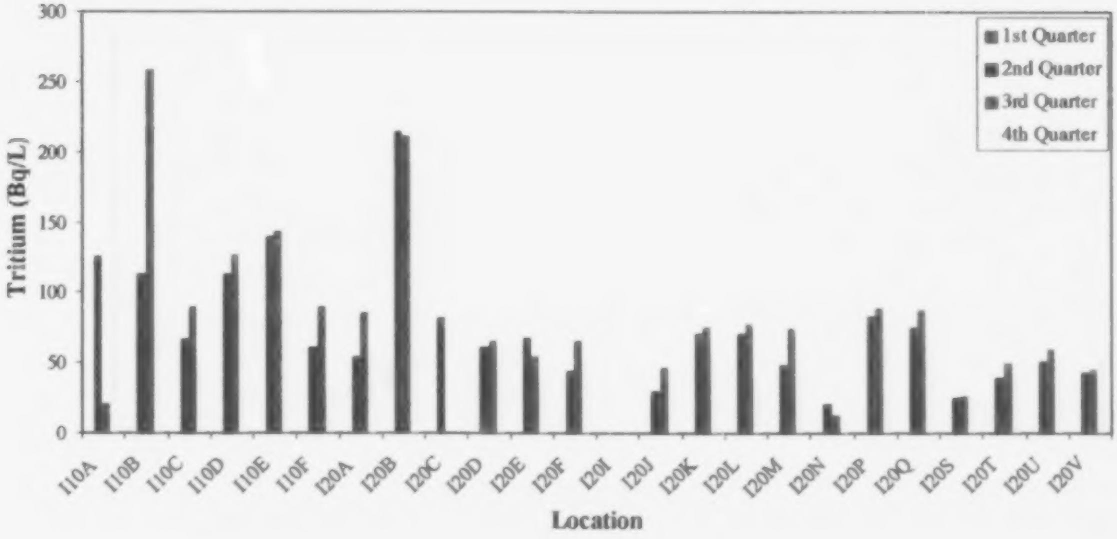

Figure 4.16: Tritium in Bore Hole Water

Table 4.27: Bore Hole Water SRWMF - Phase 1 (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
H-3	18	1.2E+1	1.1E+1 to 1.4E+1	1.2E+2	18/18	2.1E+1 to 2.8E+2	*	*	*

*There are no Reference Stations for this sample type.

Table 4.28: Bore Hole Water SRWMF - Phase 2 (Bq/L)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
H-3	49	1.2E+1	1.1E+1 to 1.3E+1	6.4E+1	49/49	1.2E+1 to 2.2E+2	*	*	*

*There are no Reference Stations for this sample type.

4.30 Parshall Flume Water (SRWMF)

Tritium from PLGS was detected in 105 of 107 samples analysed. No other radionuclides attributable to the operation of PLGS were detected.

Rainwater and snow melt at the SRWMF (Phase 1 and 2) are obtained from drainage channels (flumes) constructed to collect surface runoff from these areas. Samples are collected and analysed on a weekly basis.

There is little or no flow into or out of these collection locations during the winter months and values for H-3 tend to vary little from one week to the next except after heavy rain. The average value at Phase 2 is 64 Bq/L, much less than 750 Bq/L at Phase 1. The Phase 1 results are due to H-3 vapour escaping from the structures and condensing onto surfaces. Tables 4.29 and 4.30 are summaries of the detected radionuclides in the flumes. Figure 4.17 compares the H-3 in the samples from the two facilities.

"Less Than" values are plotted for non-detected results.

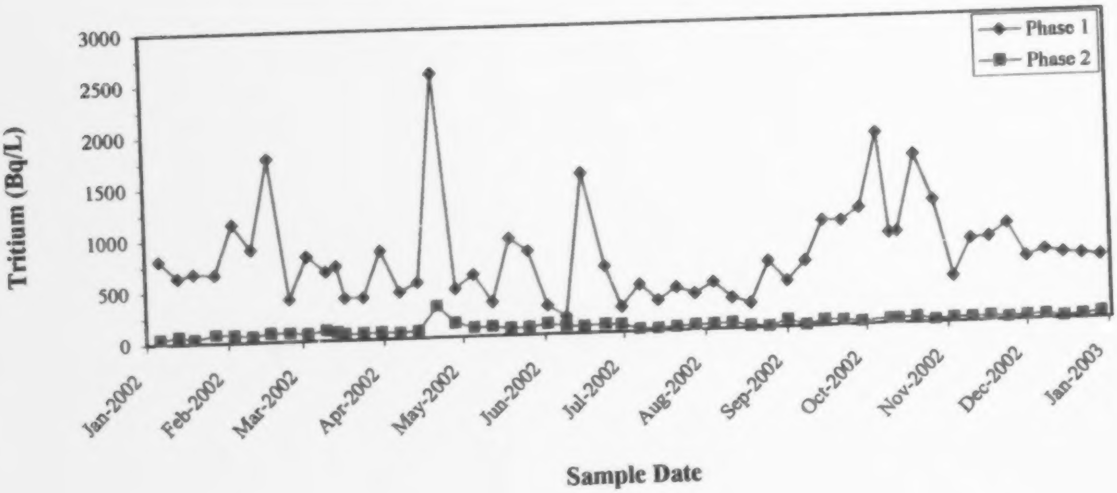

Figure 4.17: Tritium in Parshall Flume Water

Table 4.29: Parshall Flume Water SRWMF - Phase 1 (Bq/L)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	***Range***	***Mean***	***Frequency***	***Range***	***Mean***	***Frequency***	***Range***
H-3	54	1.2E+1	1.0E+1 to 1.3E+1	7.5E+2	54/54	1.7E+2 to 2.6E+3	*	*	*

* There are no Reference Stations for this sample type.

Table 4.30: Parshall Flume SRWMF - Phase 2 (Bq/L)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
H-3	53	1.2E+1	1.0E+1 to 1.3E+1	6.4E+1	51/53	1.9E+1 to 3.1 E+2	*	*	*

* There are no Reference Stations for this sample type.

4.31 Drop-off TLDs (SRWMF - Phase 2)

The measured radiation decreases as the distance from the SRWMF - Phase 2 increases.

Ambient gamma radiation is measured by TLDs placed at 17 locations in two directions from the boundary fence of Phase 2. These measure drop-off of radiation with distance from the filled dry fuel storage canisters, to about 100 metres. TLDs are changed quarterly

Results are presented in Table 4.31.

There were 98 concrete canisters filled to the end of 2002 with 52 920 used-fuel bundles. Radiation drop-off measurements (Figure 4.18) with increasing distance away from the fence show distinct differences. The "A" direction (mostly swamp after 20 m from the fence) covers drop-off to the northeast away from the perimeter fence. The "B" direction (mostly rock with some shallow sandy overburden) covers drop-off to the northwest away from the perimeter (after 75 m the TLDs are shielded from the facility by the high ground). "B" TLDs are closer to freshly filled canisters than "A" TLDs. This will change next year as a new row of canisters is filled.

The TLD locations furthest from the facility in the "B" direction (B9 and B10) were discontinued in 2001. They are hazardous for personnel to access. Since they are shielded from the facility by high ground, they provided limited useful information.

Table 4.31: TLD, Drop-off (µGy)

	Dose (µGy ± 10%)				
Location	*1st Quarter*	*2nd Quarter*	*3rd Quarter*	*4th Quarter*	*Year*
A 5m	184 ± 18	234 ± 23	202 ± 20	268 ± 27	**890 ± 40**
A 10m	184 ± 18	231 ± 23	209 ± 21	263 ± 26	**890 ± 40**
A 15m	146 ± 15	198 ± 20	152 ± 15	221 ± 22	**720 ± 40**
A 20m	112 ± 11	142 ± 14	110 ± 11	161 ± 16	**530 ± 30**
A 25m	91 ± 9	109 ± 11	99 ± 10	133 ± 13	**430 ± 20**
A 50m	78 ± 8	125 ± 13	83 ± 8	129 ± 13	**420 ± 20**
A 75m	87 ± 9	109 ± 11	80 ± 8	124 ± 12	**400 ± 20**
A 100m	81 ± 8	111 ± 11	79 ± 8	120 ± 12	**390 ± 20**
A 118m	97 ± 10	124 ± 12	106 ± 11	114 ± 11	**440 ± 20**
B 5m	288 ± 29	319 ± 32	278 ± 28	337 ± 34	**1220 ± 60**
B 10m	208 ± 21	293 ± 29	273 ± 27	356 ± 36	**1130 ± 60**
B 15m	198 ± 20	262 ± 26	215 ± 21	272 ± 27	**950 ± 50**
B 20m	188 ± 19	212 ± 21	198 ± 20	216 ± 22	**820 ± 40**
B 25m	185 ± 18	243 ± 24	185 ± 19	233 ± 23	**850 ± 40**
B 50m	156 ± 16	190 ± 19	163 ± 16	211 ± 21	**720 ± 40**
B 75m	147 ± 15	188 ± 19	153 ± 15	209 ± 21	**700 ± 40**
B 100m	178 ± 18	207 ± 21	188 ± 19	230 ± 23	**800 ± 40**
B 150m	suspended at the end of 2001				
B 200m	suspended at the end of 2001				

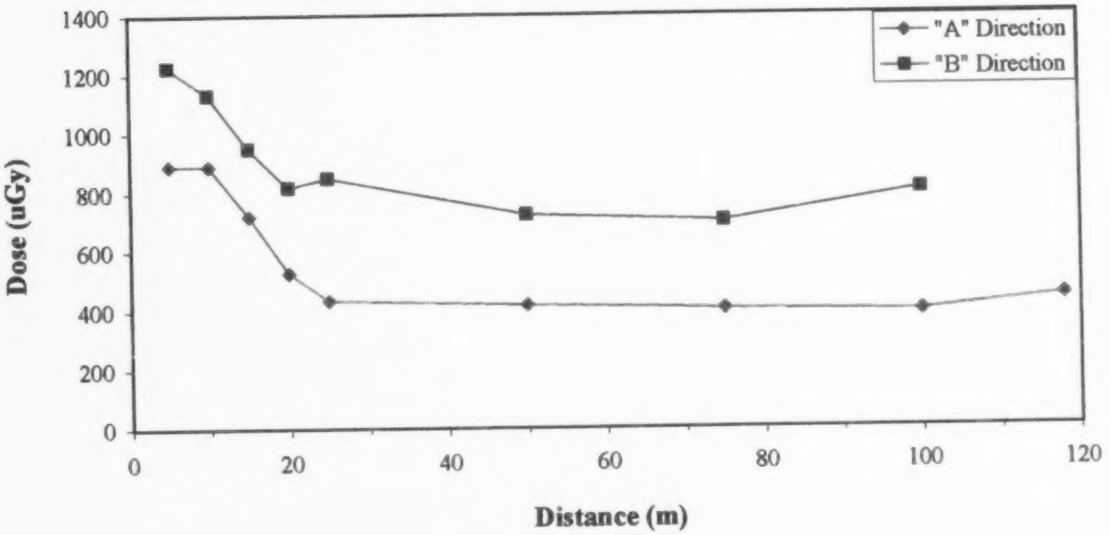

Figure 4.18: Drop-off TLDs

4.32 Hemlock Knoll Regional Sanitary Landfill

In December 1999, PLGS began disposing of its non-active waste at the public landfill facility. A monitoring program was established prior to the first shipment. It includes sampling of water from the leachate, bore holes and various holding ponds, and dosimeter placement at key locations.

There were 35 water samples and 20 TLD results. Tritium was detected in 16 of the 35 water samples. Table 4.32 summarises the water sample results. There were no other radionuclides detected, other than naturally occurring isotopes that are not reported here. TLD results appear in Table 4.06 (location codes YTL1 to YTL5).

In 2001, the leachate from Crane Mountain Regional Sanitary Landfill was analysed and found to have similar H-3 levels. PLGS does not ship waste to that facility. The source of H-3 in both of these landfills is suspected to be H-3 in commercial and consumer devices (e.g., H-3 powered "Exit" signs).

Due to the hazard to field personnel, soil and gamma surveys from the disposal cell were discontinued in 2001. Since fresh soil is used to cover the cell, no useful information was obtained.

Table 4.32: Liquid (Bq/L) Hemlock Knoll Regional Sanitary Landfill

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
H-3	35	5.6E+1	8.9E+0 to 7.3E+1	3.4E+2	12/35	1.0E+1 to 7.0E+2	*	*	*

* There are no Reference Stations for this sample type.

4.33 Meteorological Data

A problem was discovered in the meteorological data for the years 1992 to 2000: the temperature reading from the 42-metre elevation (at the Point Lepreau Generating Station tower) contained a bias that affected the calculation of the Pasquill Stability factor. This has no effect on the program. It is presented here for information purposes only. The meteorological data for 2002, and a compilation of the available 1986 to 2002 data, have this information removed and are presented in Tables 4.33 and 4.34. Data were collected hourly. Wind Rose data for 2002 are presented in Figure 4.19 and a pie-plot of the average percentage frequency of Pasquill stability classes for the years from 1986 to 1991 in the Point Lepreau area is presented in Figure 4.20.

Table 4.33: Meteorological Data for Point Lepreau (2002)

	Temperature (Degrees Celsius) 10 Metre Tower Data					*Wind Direction* (Relative %) 42 Metre Tower Data*							
		Mean Daily		*Extreme*		*%Observations from*							
Month	***Avg***	***Max***	***Min***	***Max***	***Min***	***N***	***NE***	***E***	***SE***	***S***	***SW***	***W***	***NW***
January	-2.8	0.7	-7.0	6.7	-14.3	17	10	4	3	6	15	27	19
February	-2.9	1.8	-7.4	9.6	-21.1	14	11	7	13	11	8	19	17
March	0.0	3.4	-4.0	11.4	-9.9	8	15	8	13	9	18	19	10
April	4.0	6.7	1.6	14.2	-3.6	16	13	4	13	17	13	14	11
May	7.6	11.0	5.1	17.5	2.1	2	11	4	23	26	18	11	6
June	10.2	13.2	7.3	21.7	4.1	10	25	2	11	22	8	14	8
July	15.7	19.7	12.7	29.5	9.8	7	15	6	16	24	11	13	7
August	16.5	20.3	13.4	23.8	7.4	11	12	5	17	22	15	7	11
September	14.7	17.6	12.0	23.7	7.4	8	14	5	11	26	16	12	8
October	6.5	9.8	3.3	15.5	-3.7	8	15	6	8	3	8	35	16
November	2.7	6.2	-0.6	14.3	-9.0	17	9	6	8	10	12	23	14
December	-2.0	1.9	-5.6	11.9	-18.5	8	7	6	3	5	21	37	12
Annual	Mean 4.9	Mean 8.4	Mean 1.6	Extreme 29.5	Extreme -21.1	11	12	5	11	14	14	20	12
Years	1	1	1	1	1	1	1	1	1	1	1	1	1

*Each compass direction covers ±22.5 degrees

Table 4.34: Meteorological Data for Point Lepreau (average 1986 to 1991)

Month	Temperature (Degrees Celsius)					Wind Direction* Relative % Observation From								Relative % Pasquill Stability Classes							% UNAV
	Avg	Mean Daily		Extreme																	
		Max	Min	Max	Min	N	NE	E	SE	S	SW	W	NW	A	B	C	D	E	F	G	
January	-4.9	-0.8	-8.9	7.2	-25.3	11	10	4	5	10	19	18	23	19	9	8	26	22	12	5	3
February	-5.4	-1.8	-9.4	7.3	-21.9	16	8	3	4	11	22	15	23	22	11	11	23	19	9	5	1
March	-1.5	1.5	-4.7	13.5	-24.9	19	13	4	5	15	17	9	19	16	8	8	25	25	12	7	2
April	3.3	5.9	1.1	16.4	-4.2	20	25	6	6	17	13	8	5	12	5	7	25	33	12	6	15
May	7.9	11.2	5.5	25.6	-0.7	13	19	6	6	22	22	7	5	8	4	6	21	32	17	13	18
June	11.4	14.6	9.0	26.1	4.1	8	17	7	6	20	23	12	8	4	2	3	16	36	23	16	14
July	14.4	17.3	12.0	25.2	6.9	5	12	5	7	25	31	10	6	2	1	2	11	31	27	27	9
August	14.8	17.5	12.7	25.0	8.3	6	10	5	8	23	27	14	8	2	1	1	9	29	33	26	7
September	12.0	14.4	9.9	26.3	1.1	8	9	4	6	20	24	16	14	5	2	3	18	34	25	13	6
October	8.4	10.7	6.1	18.9	-1.7	13	10	7	9	19	18	14	11	5	4	5	27	30	17	12	3
November	2.8	5.7	-0.2	14.5	-13.7	13	9	4	7	11	13	22	23	9	5	8	34	25	15	4	1
December	-4.0	-0.1	-8.0	11.1	-21.1	13	6	5	3	7	13	25	28	18	11	11	27	21	9	3	5
Period	Mean 4.9	Mean 8.1	Mean 2.2	Extreme 26.3	Extreme -25.3	12	12	5	6	17	20	14	15	10	5	6	22	28	18	11	7
Years	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

42 Metre Tower data

*Each compass direction covers ±22.5 degrees

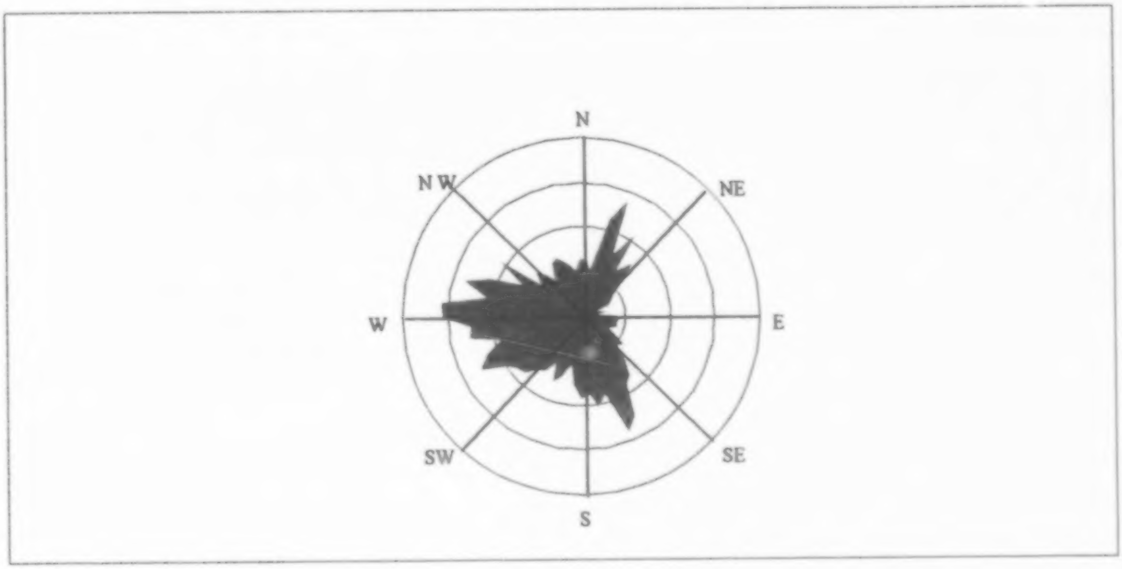

Figure 4.19: Wind Rose for Point Lepreau (2002)

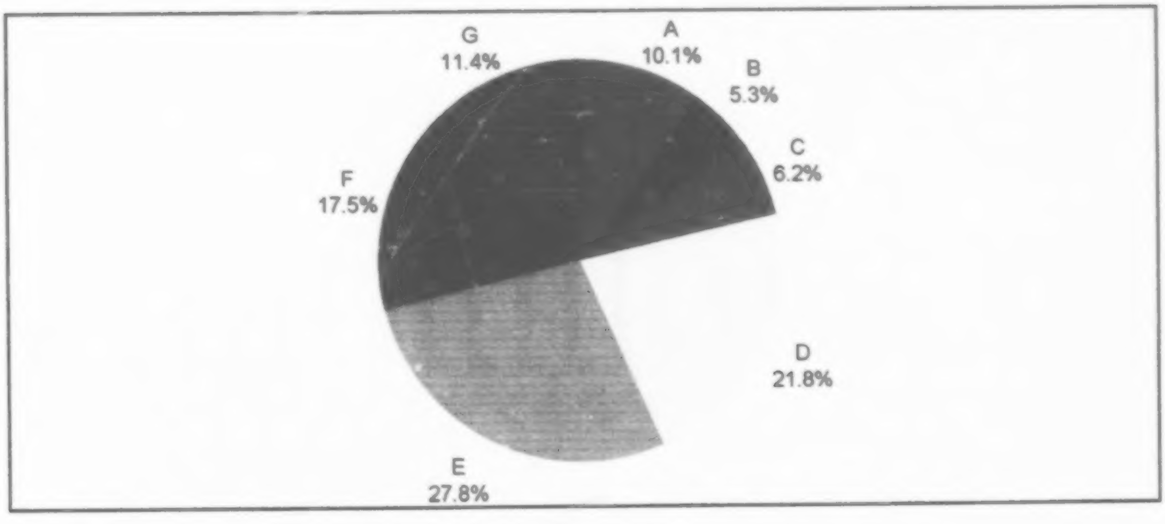

Figure 4.20: Pasquill Stability Factors for Point Lepreau (1986 to 1991)

5 Trends

The only trend that was obvious from the historical data was increasing H-3 in Parshall Flume water from the SRWMF-Phase 1 (Figure 5.20). However, this trend did not continue into 2002.

As in the figures in Section 4, "Less Than" values are plotted for non-detected values. All location codes are described in Appendix C.

5.01 Dose from Airborne and Liquid Pathways

Radiation dose from PLGS emissions continues to be well below the public dose limit (1000 microsieverts per annum), and also well below the design and operating target for PLGS (50 microsieverts per annum). See Figure 5.01.

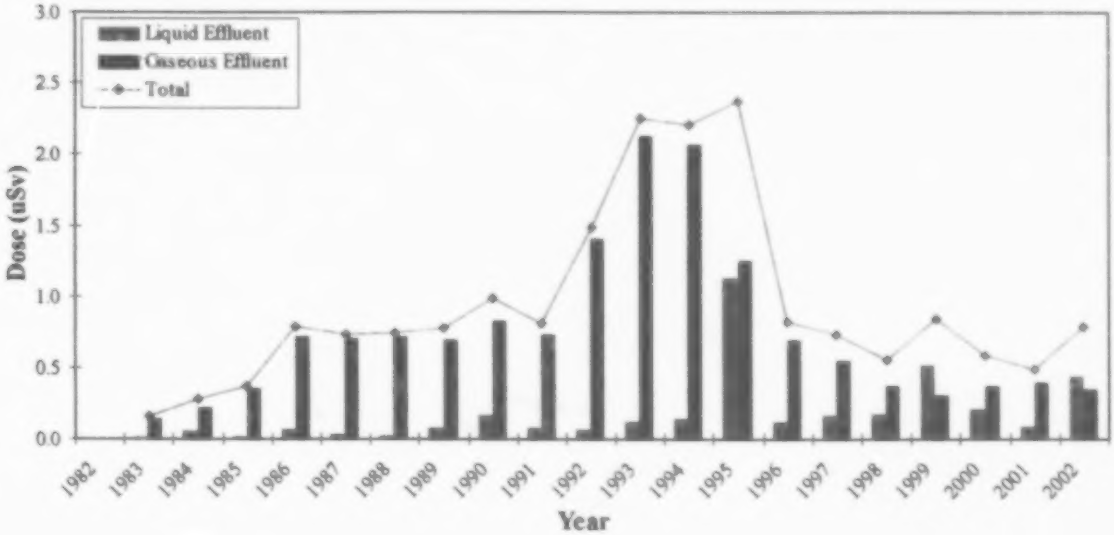

Figure 5.01: Dose from Airborne and Liquid Pathways

5.02 Gross Beta in Air

Figures 5.02 and 5.03 show the gross beta data for all air stations since the NB Power program began in 1976. A plot of the gross beta data from Dipper Harbour, about 4 km from the PLGS stack and in the predominant downwind direction, is presented in Figure 5.04. The baseline data show the naturally occurring radioactivity in the area. The peaks on the plots correspond to fallout from various atmospheric bomb tests that were most common in the 1950s and 1960s but decreased into the 1970s. Fallout from the Chinese atmospheric bomb test in October of 1980 (fallout occurred in 1981 in N.B.), and from the Chernobyl accident in April 1986, were obvious. Figure 5.05 shows a comparable plot of data from Health and Welfare Canada, but for the whole of Canada from 1959 (when data were first collected) to 1991. The scale is very much condensed to allow the bomb test fallout levels to be kept on-scale.

The Chernobyl accident released, in a period of a few days, about 1% as much radioactivity to the environment as all of the U.S. atmospheric bomb tests combined, released over several years.

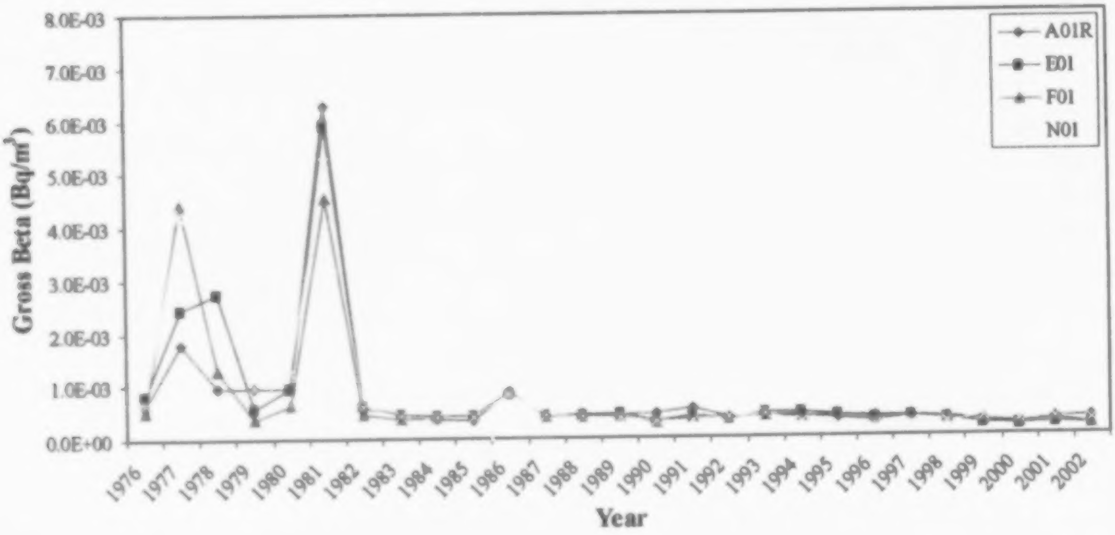

Figure 5.02: Gross Beta in Air (Offsite Air Stations)

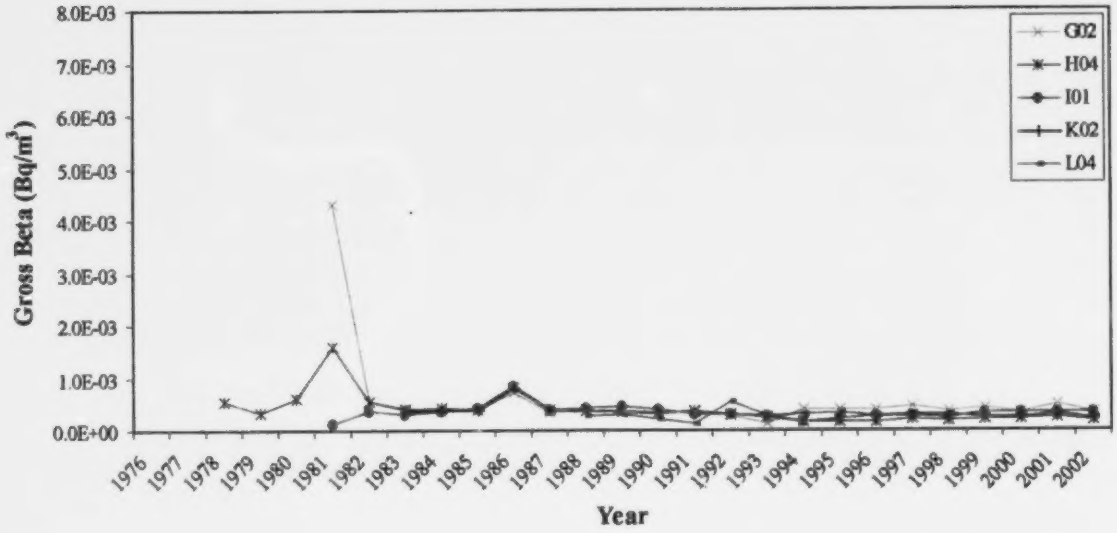

Figure 5.03: Gross Beta in Air (Onsite Air Stations)

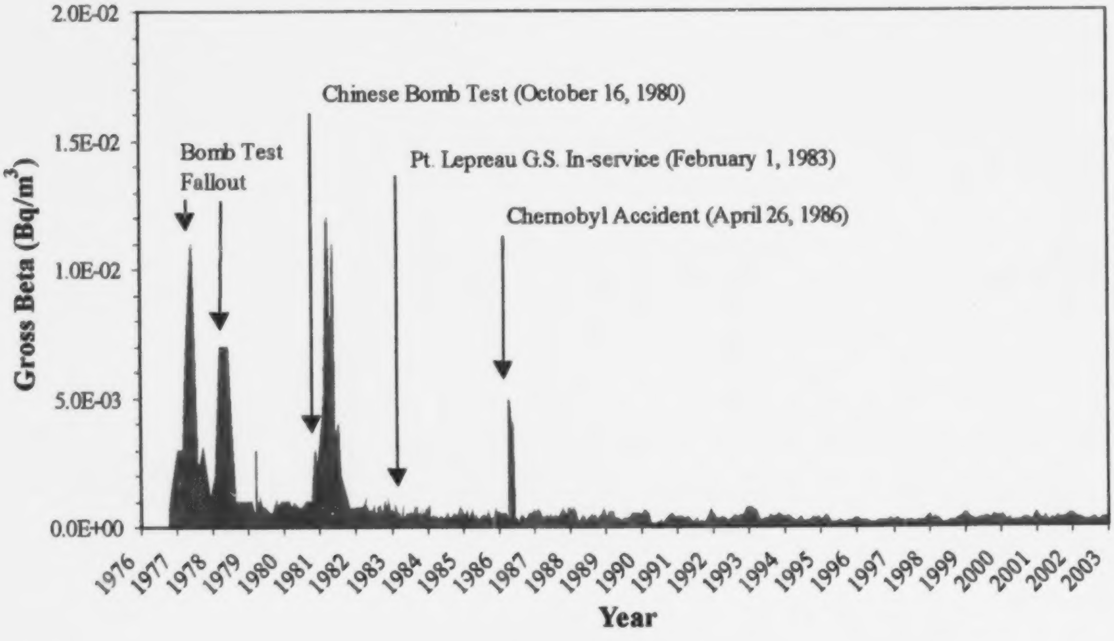

Figure 5.04: Gross Beta Activity in Air at Dipper Harbour

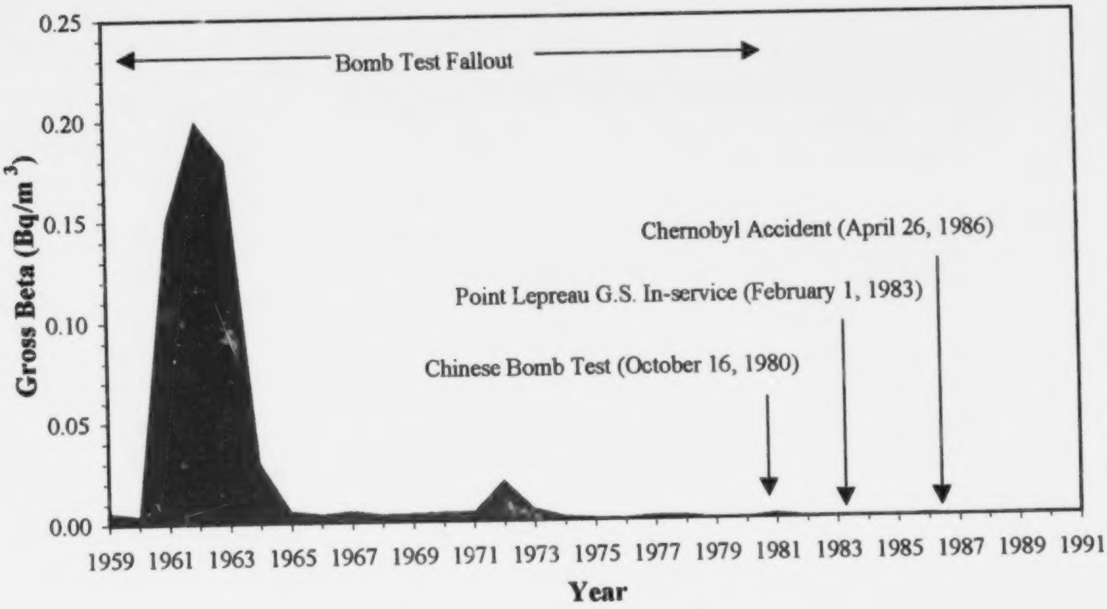

Figure 5.05: Annual Average Gross Beta Activity in Air for Canada 1959 to 1991 (Health and Welfare Canada Data)

5.03 Tritiated Water in Air

The onsite stations show a decline since the peak in 1993/1994, as have station airborne tritium emissions. See Figures 5.06 and 5.07.

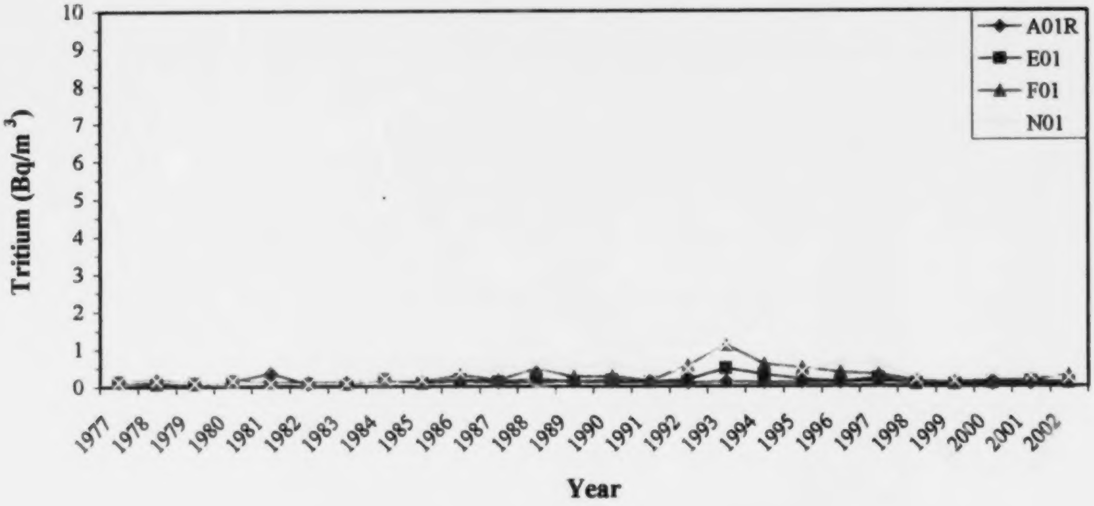

Figure 5.06: Tritiated Water in Air (Offsite)

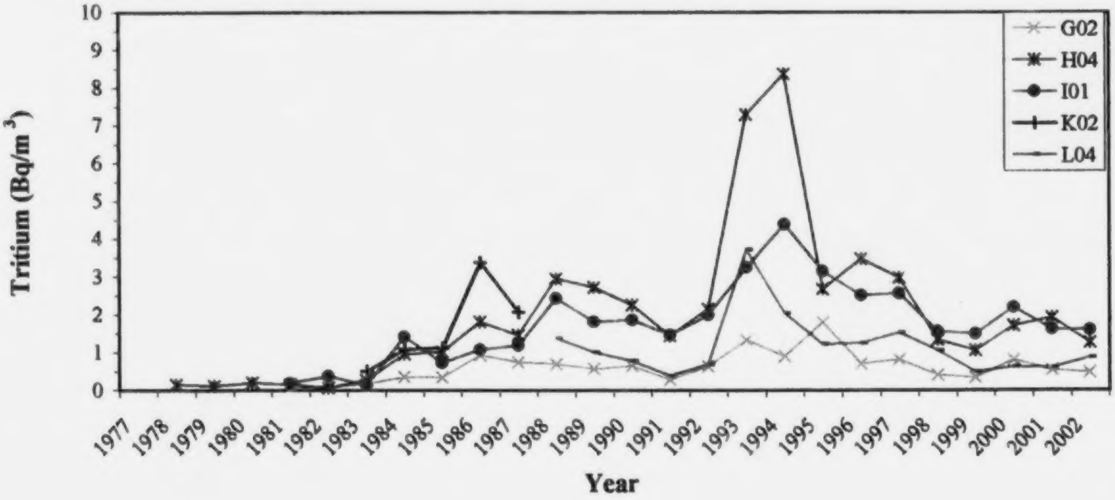

Figure 5.07: Tritiated Water in Air (Onsite)

5.04 Atmospheric Dispersion Factors

The annual average dispersion factor for stack emissions up to this time is between 1E-7 and 2E-7 s/m^3. This factor is based upon the data for H-3. A value of 2E-7, based on such empirical data, is used in the DEL calculations. Results since 1984 are presented in Table 5.02.

In the calculation of the mean dispersion factor at each location, the average recorded is now the average of the detected values and the "Less Than" values. This will give a conservative estimate of the true value (i.e., less dispersion of the radionuclides).

To derive a normalised mean dispersion factor at 1 km from the stack for all locations, each dispersion factor value is corrected to 1 km. This is accomplished by tracing back between dispersion curves on the graph of "Weighted Mean Dilution Factor versus Distance from the Point of Continuous Emission"(12). The average of these normalised values is presented in Table 5.01.

Table 5.01: Normalised Mean Dispersion Factor at 1 km for All Indicator Locations

Year	*Dispersion Factor (s/m^3)*
1984	2E-07
1985	1E-07
1986	1E-07
1987	1E-07
1988	2E-07
1989	2E-07
1990	1E-07
1991	1E-07
1992	1E-07
1993	1E-07
1994	1E-07
1995	2E-07
1996	2E-07
1997	2E-07
1998	2E-07
1999	2E-07
2000	2E-07
2001	2E-07
2002	2E-07
Average over 19 years	<2E-07

Table 5.02: Average Atmospheric Dispersion Factor for Each Air Monitoring Location

Location Code		***E01***	***F01***	***G02***	***H04***	***I01***	***K02***	***L04***	***N01***
Location		***Maces Bay***	***Welch Cove***	***Lepreau Lighthouse***	***Old Site of Information Centre***	***SRWMF***	***CCW Pumphouse***	***Construction Stores***	***Dipper Harbour***
Distance from PLGS		***4.5 km***	***1.6 km***	***1.0 km***	***0.75 km***	***1.2 km***	***0.2 km***	***0.55 km***	***3.7 km***
Year	***Release (Bq)***	***Dispersion Factor (s/m^3)***							
1984	6.8E+13	8E-8	8E-8	2E-7	5E-7	7E-7**	5E-7	-	8E-8
1985	1.1E+14	2E-8	4E-8	9E-8	3E-7	2E-7	3E-7	-	5E-8
1986	2.0E+14	3E-8	5E-8	1E-7	3E-7	2E-7	5E-7	-	6E-8
1987	2.2E+14	2E-8	2E-8	1E-7	2E-7	2E-7	3E-7	-	7E-8
1988	2.2E+14	3E-8	7E-8	1E-7	4E-7	3E-7	#	2E-7	9E-8
1989	2.1E+14	2E-8	4E-8	8E-8	4E-7	3E-7	#	2E-7	8E-8
1990	2.5E+14	2E-8	3E-8	8E-8	3E-7	2E-7	#	1E-7	8E-8
1991	1.7E+14	2E-8	3E-8	5E-8	3E-7	3E-7	#	7E-8	7E-8
1992	3.6E+14	2E-8	5E-8	5E-8	2E-7	2E-7	#	6E-8	4E-8
1993	6.4E+14	2E-8	5E-8	6E-8	4E-7	2E-7	#	2E-7	5E-8
1994	5.6E+14	2E-8	3E-8	5E-8	5E-7	2E-7	#	1E-7	1E-7
1995	3.1E+14	2E-8	5E-8	2E-7	3E-7	3E-7	#	1E-7	4E-8
1996	2.4E+14	2E-8	5E-8	9E-8	5E-7	3E-7	#	2E-7	8E-8
1997	2.1E+14	3E-8	5E-8	1E-7	4E-7	4E-7	#	2E-7	9E-8
1998	1.3E+14	2E-8	3E-8	1E-7	3E-7	4E-7	#	3E-7	5E-8
1999	9.5E+13	7E-8	5E-8	1E-7	3E-7	5E-7	#	1E-7	1E-7
2000	1.3E+14	2E-8	3E-8	2E-7	4E-7	5E-7	#	1E-7	8E-8
2001	1.3E+14	9E-8	5E-8	1E-7	4E-7	4E-7	#	1E-7	2E-7
2002	1.3E+14	2E-8	7E-8	1E-7	3E-7	4E-7	#	2E-7	5E-8

**This value includes a second source term: H-3 from containers temporarily located in this facility in 1984 and picked up by the air sampler (ignored in the calculation of the normalised mean dispersion factor).

No longer in use. This monitoring station was relocated to L04 - the Construction Stores Compound - in the spring of 1988.

5.05 Strontium-90 in Air (GEM)

There have only been a few years when Sr-90 was detected in station effluents. The maximum values for Sr-90 still represent only a small fraction of the DEL and are due to activity detected just above the detection limit.

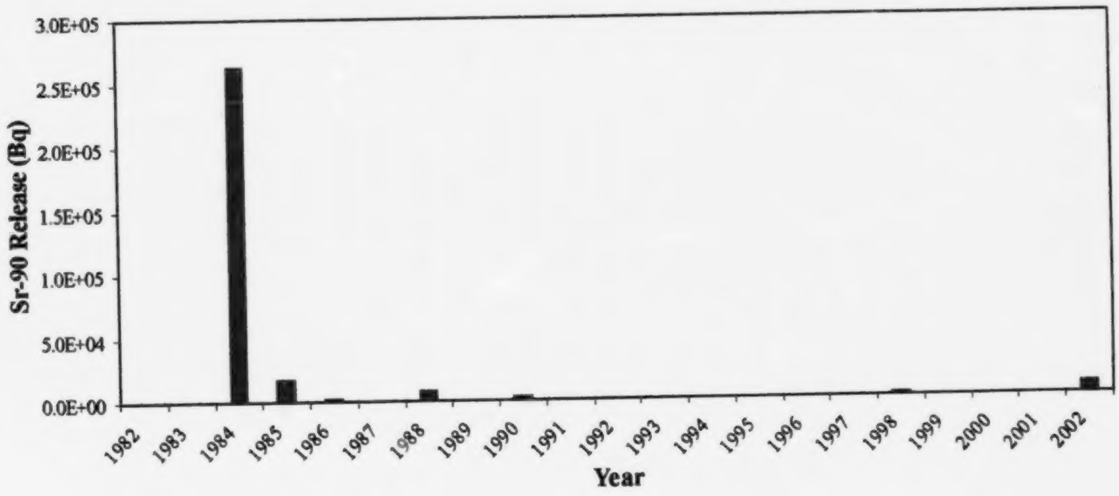

Figure 5.08: Sr-90 in Air (GEM)

5.06 TLD Measurements

A plot of summary TLD data since 1977 is presented in Figure 5.09. There is only one reference location (A01R in Bocabec) while the other groups are the average of many locations. *Boundary* refers to locations at the edge of NB Power property.

The variation in natural background radiation at any individual location covers a range of about 300 microgray from year to year. A few locations (close to the reactor building and the air emissions stack) show significant, but small, increases in gamma radiation due to chronic releases of low levels of noble gases. In 1995, the extended outage resulted in fewer noble gas emissions and thus lower dose measured by these TLDs. Small increases at the SRWMF are due to low-level waste and used fuel emplacement and not to station emissions.

Background radiation in any of the monitored residential areas has not increased from the levels measured before the Point Lepreau Generating Station was placed into operation.

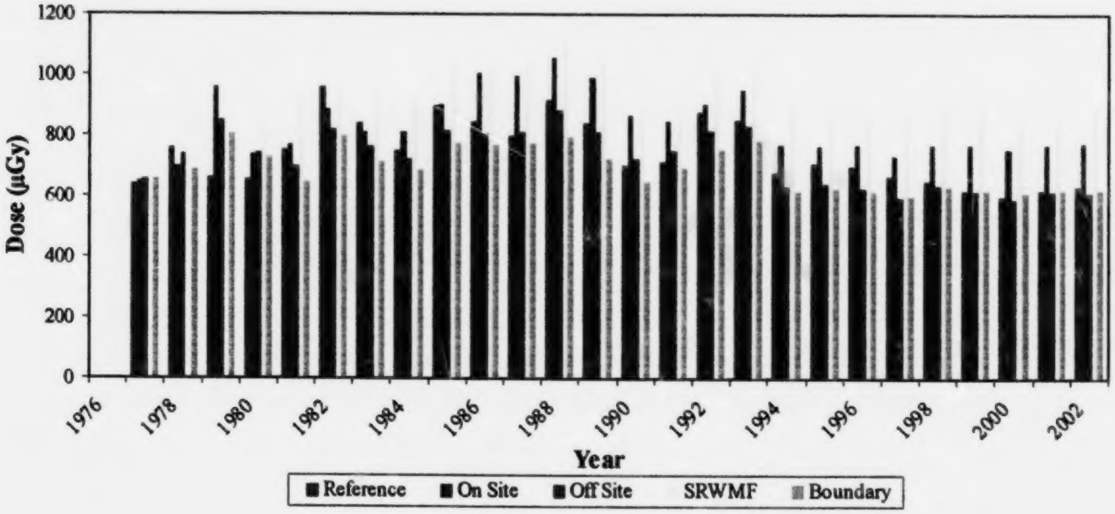

Figure 5.09: TLD Measurements

5.07 Gross Beta in Well Water

The beta activity is due to the presence of naturally occurring radionuclides (especially radon progeny). As expected, there has been no significant change in this parameter over the years.

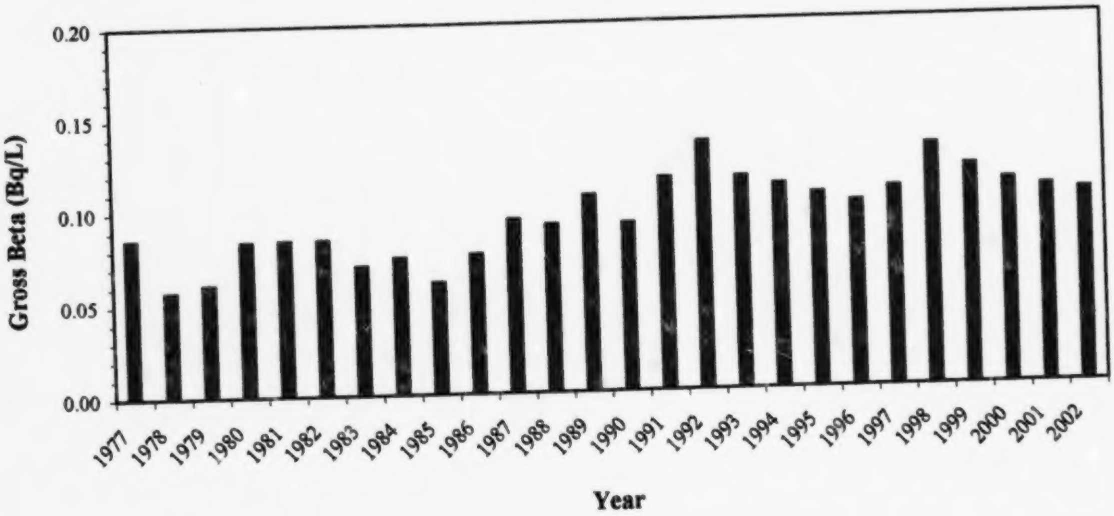

Figure 5.10: Gross Beta in Well Water

5.08 Tritium in Well Water

Precipitation and surface water contain tritium from PLGS emissions. Even though there is surface runoff into some shallow wells, there has been no significant change in this parameter over the years.

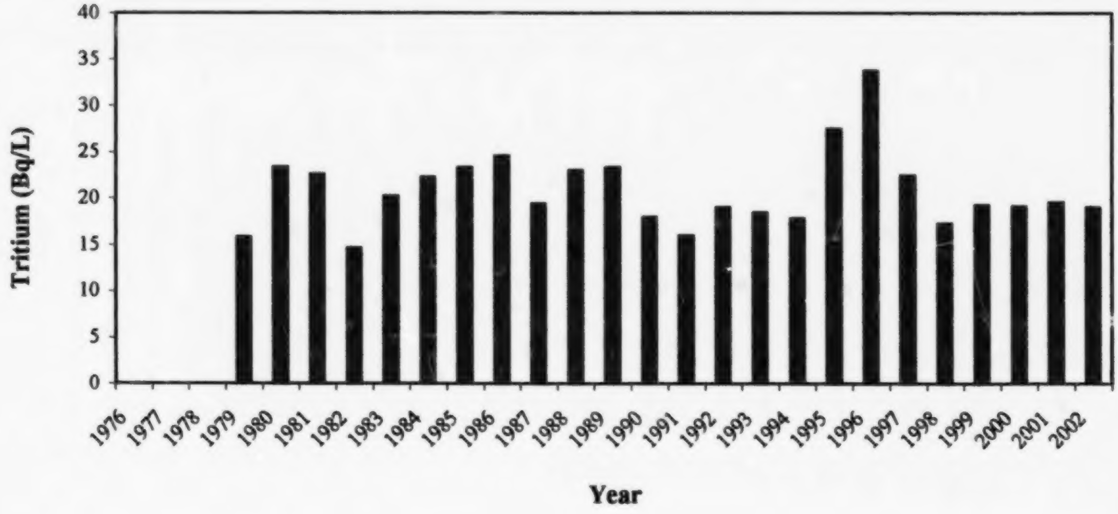

Figure 5.11: Tritium in Well Water

5.09 Cs-137 in Soil

Cesium-137 from fallout of past atmospheric bomb tests tends to accumulate in the organic layer of the soil. Any fluctuation seems to be due to this organic load in the sample. There were no soil samples from 1986 to 1992 because, at the time, this fluctuation caused it to be viewed as an unimportant sample type.

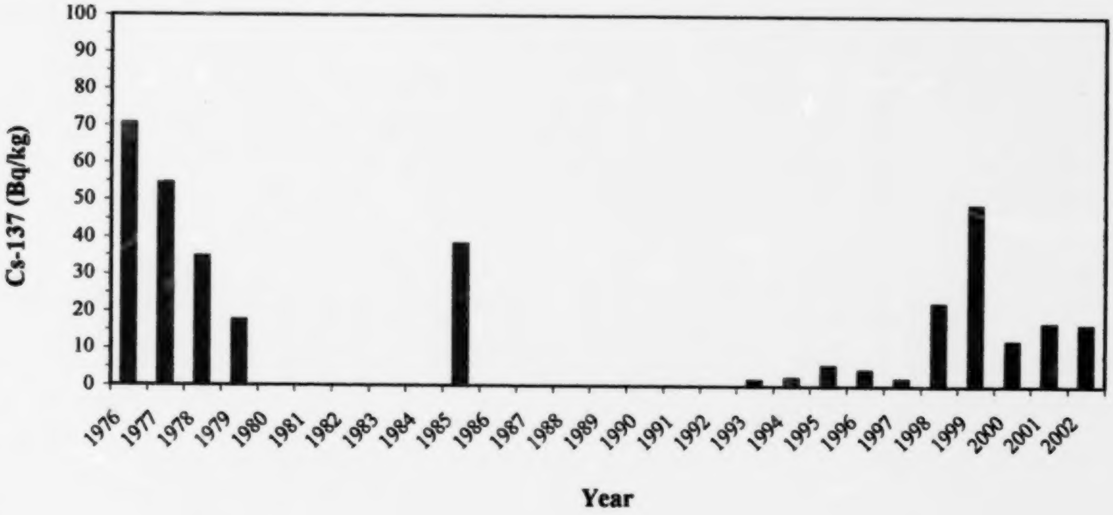

Figure 5.12: Cs-137 in Soil

5.10 Cs-137 in Sediment

The effects of the atmospheric bomb tests and the accident at Chernobyl continue to be seen here. There has been no significant change in this parameter over the years.

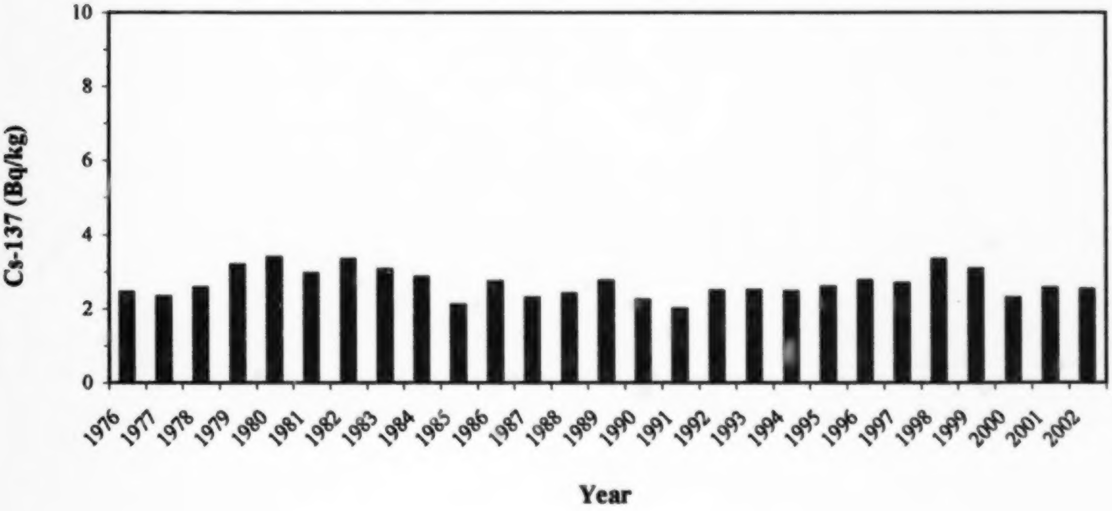

Figure 5.13: Cs-137 in Sediment

5.11 Tritium in Seawater

The increase in H-3 in 1996 and 1997 were due to samples being taken directly over the out-fall. These samples are usually taken at the shore, where the effects of tidal mixing are evident.

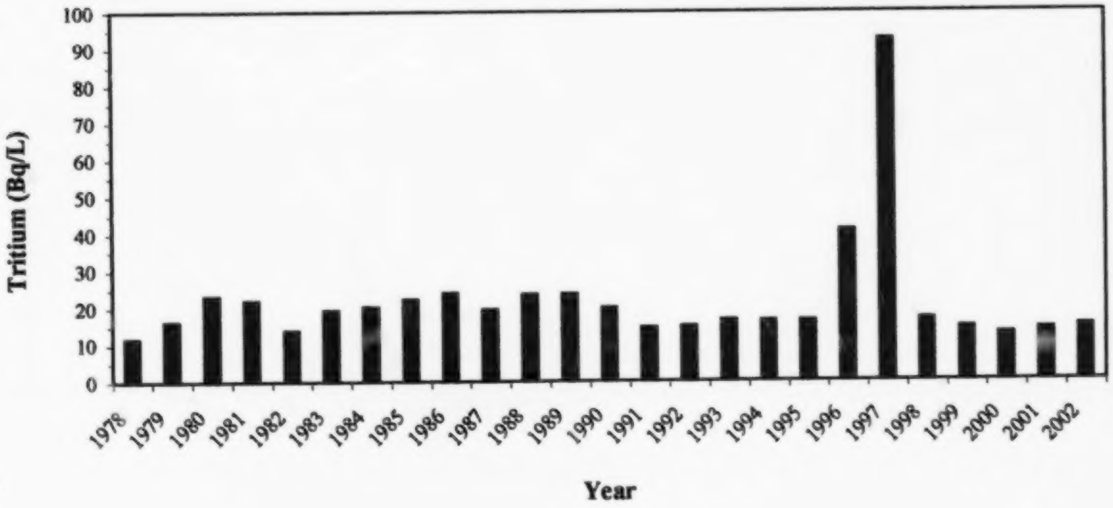

Figure 5.14: Tritium in Seawater

5.12 Strontium-90 in LEM

The maximum values for Sr-90 still represent only a small fraction of the DEL and are due to activity detected just above the detection limit.

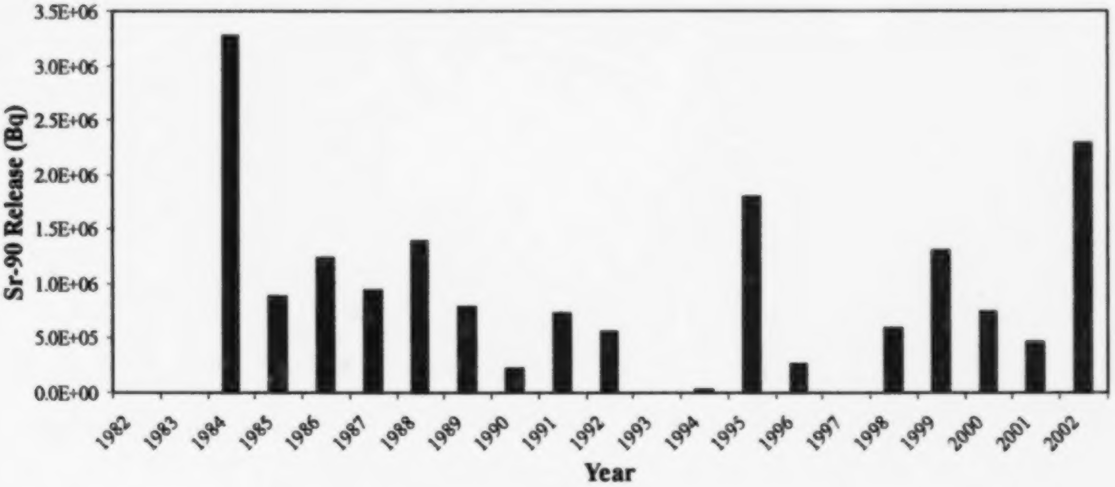

Figure 5.15: Sr-90 in LEM

5.13 Tritium in Monitoring Wells (Near Plant)

In the summer of 2000, a geotechnical firm evaluated the onsite groundwater movement and made recommendations for an improved monitoring program. Based on their advice, eleven monitoring wells near the plant were drilled.

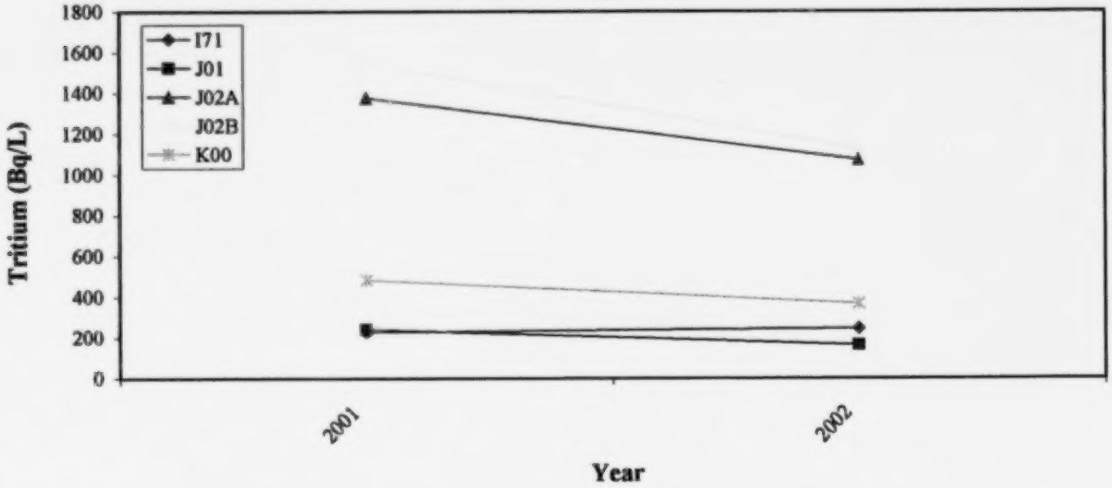

Figure 5.16: H-3 in Monitoring Wells (near plant)

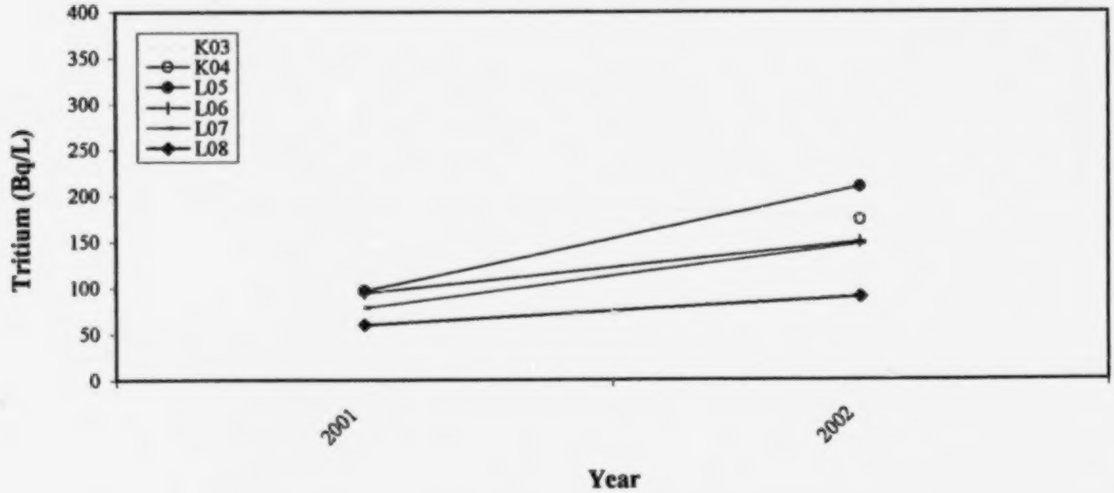

Figure 5.17: H-3 in Monitoring Wells (near plant)

5.14 Tritium in Bore Holes

In the summer of 2000, a geotechnical firm evaluated the onsite groundwater movement and made recommendations for an improved monitoring program. Based on their advice, nine new bore holes in and around the SRWMF (two older ones were retired) were drilled, bringing the total to 24. There has been a general upward trend in the Phase 1 bore hole results since the late 1980s. That trend was reversed in 2001.

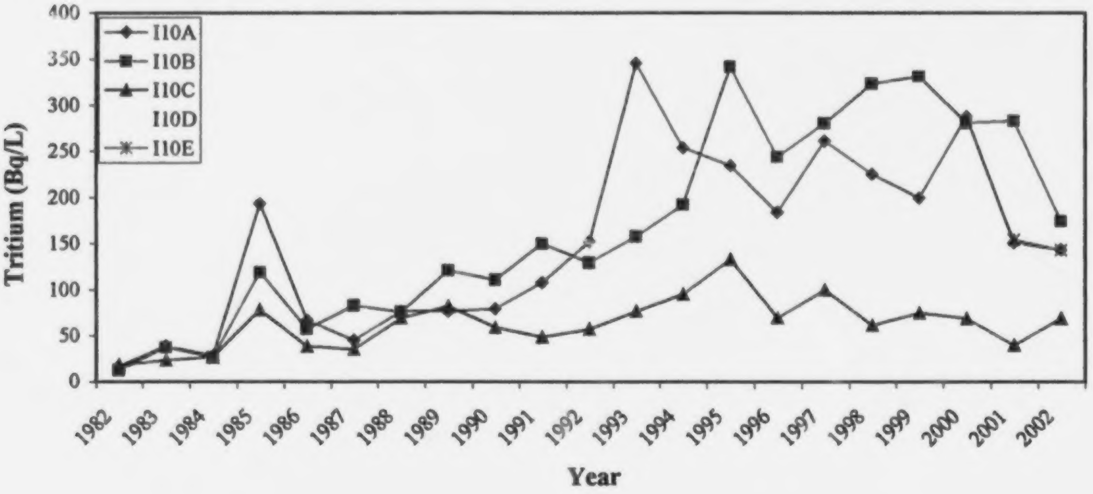

Figure 5.18: H-3 in Bore Holes

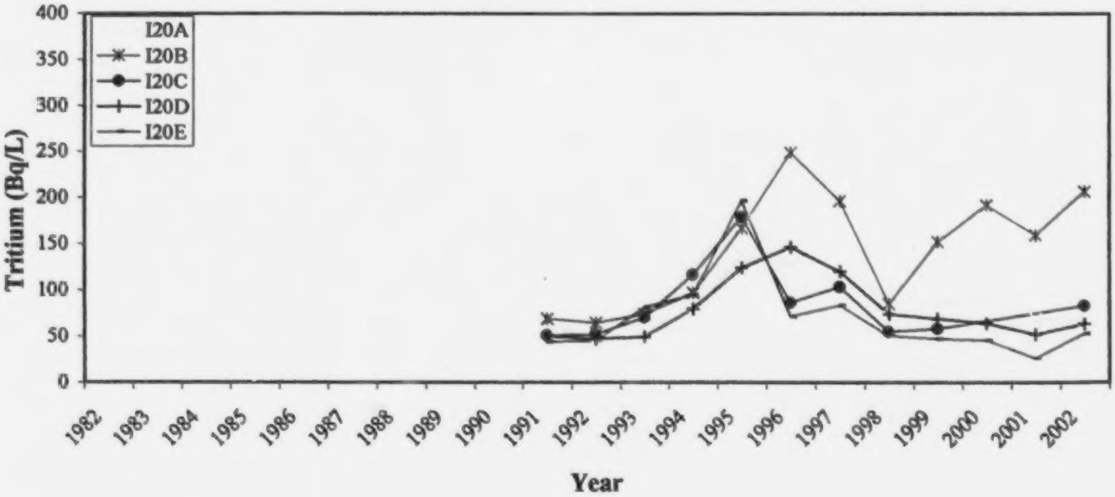

Figure 5.19: H-3 in Bore Holes

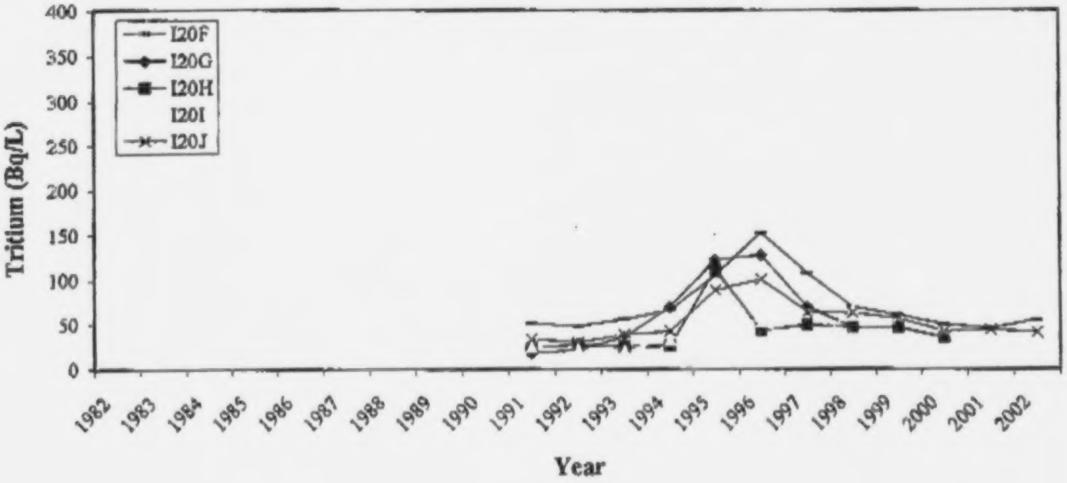

Figure 5.20: H-3 in Bore Holes

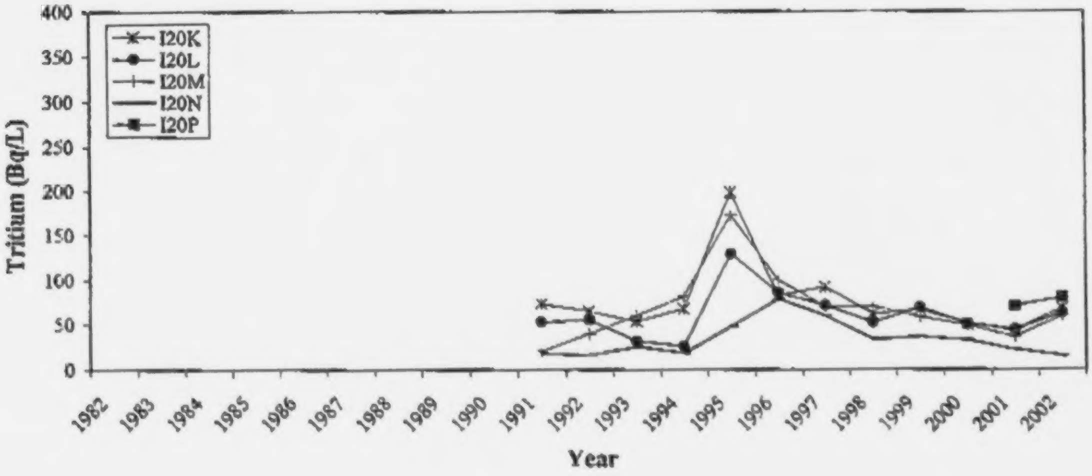

Figure 5.21: H-3 in Bore Holes

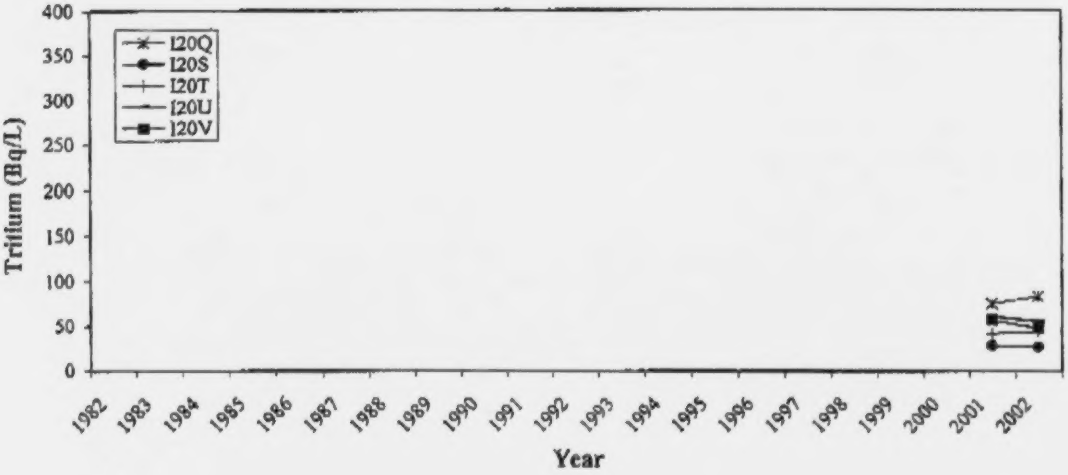

Figure 5.22: H-3 in Bore Holes

5.15 Tritium in Parshall Flume Water

The values at Phase 2 are typically less than those at Phase 1. The Phase 1 results are due to H-3 vapour escaping from the structures and condensing onto surfaces. There has been a general upward trend in the Phase 1 Parshall Flume results since the late 1980s. That trend was reversed in 2001.

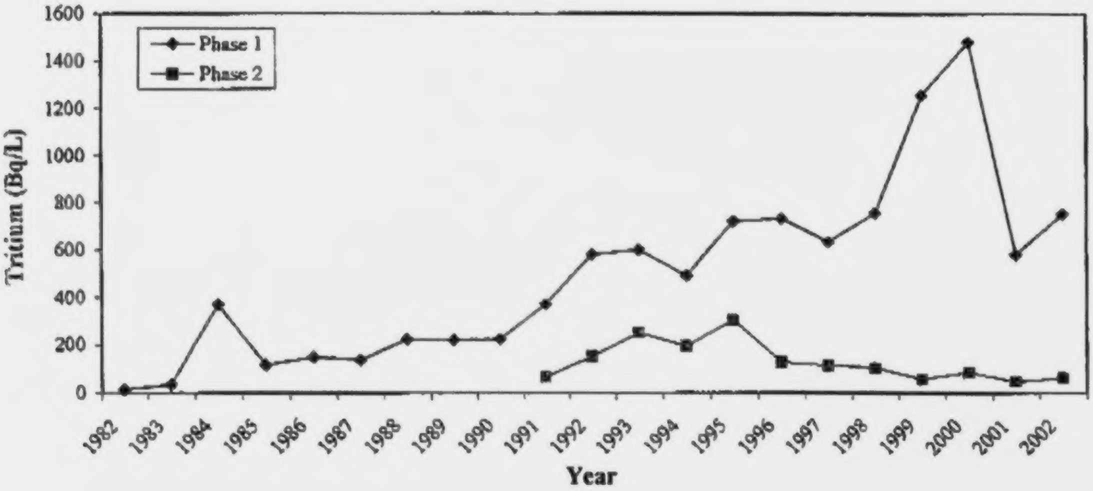

Figure 5.23: H-3 in Parshall Flumes

5.16 Drop-off TLDs

Dosimeters are in place in two directions from the boundary fence of the SRWMF - Phase 2 facility to measure drop-off of radiation from the filled dry fuel storage canisters with distance, to about 100 metres. Results are presented in Figure 5.24. Each point on the graph is the average for all the years the facility has operated. The "B" direction is higher than the "A" direction because the rocky terrain (after 20 m) has a higher natural background. However, the pattern of filling the canisters affects the reading on the first few TLDs in the "B" direction. These TLDs have read higher in recent years than the "A" TLDs because they are closer to full canisters. This should change next year as a new row of canisters, closer to the "A" TLDs, is filled.

The bar charts in Figure 5.25 and Figure 5.26 present the annual dose for each location (since 1991).

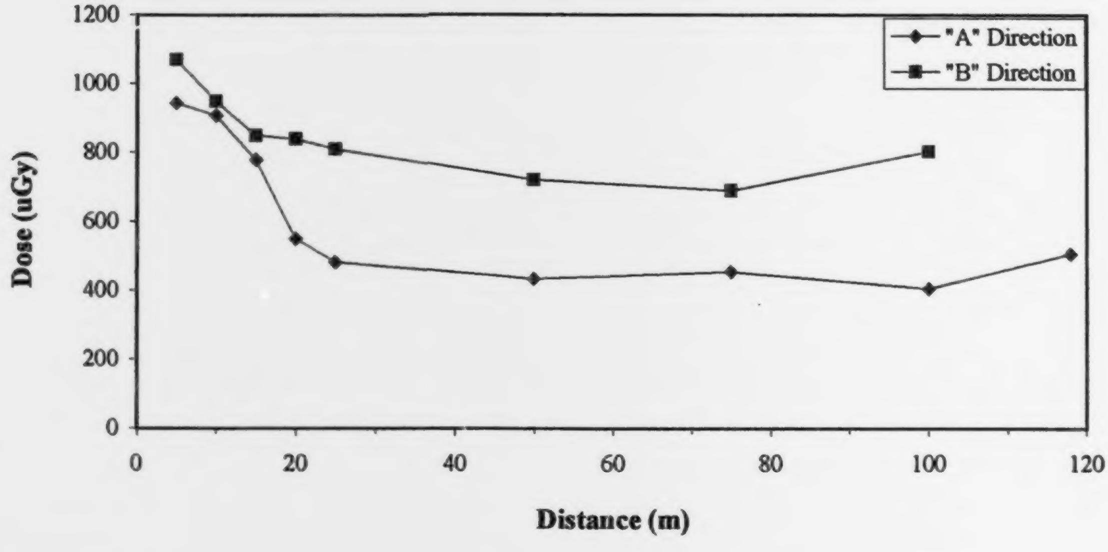

Figure 5.24: Drop-off TLDs

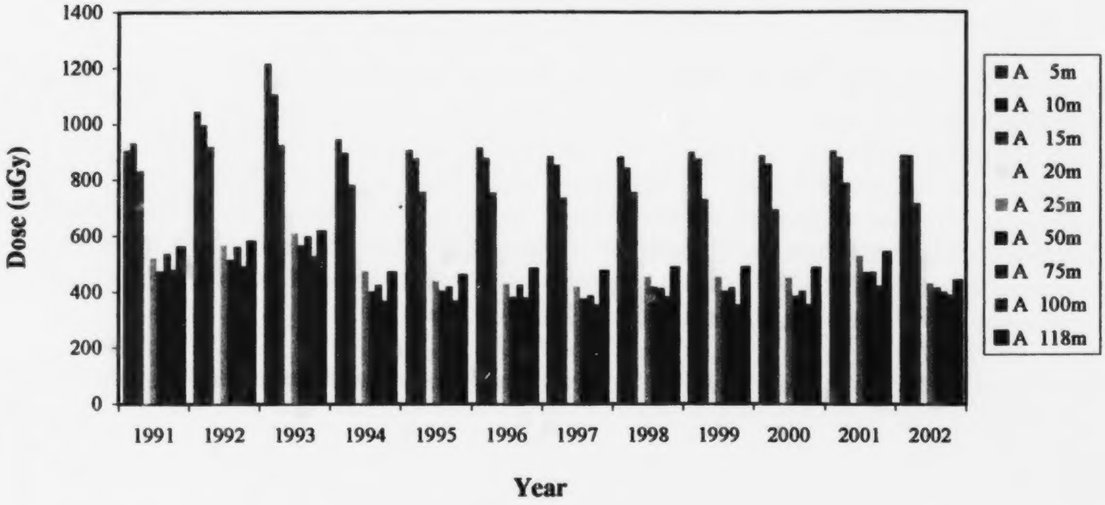

Figure 5.25: Drop-off TLDs

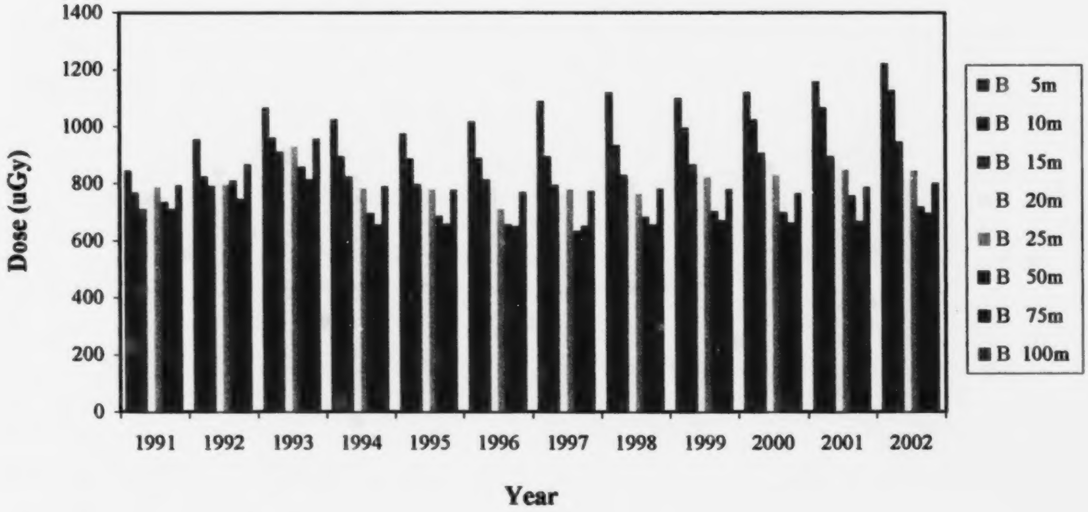

Figure 5.26: Drop-off TLDs

6 Dose Estimation

Based upon the total percent DEL for all monitored radionuclides in each pathway for 2002, the calculated annual whole body radiation dose to members of the Critical Groups was about 0.44 μSv from liquid emissions and about 0.35 μSv from airborne emissions. This latter calculation allows for the actual location of an existing dairy herd in 2002 at about 40 km, rather than assuming the existence of a hypothetical herd at 1.5 km. This results in a dose reduction factor of about 12 for C-14 in the milk pathway because of the differences in dispersion factors between 1.5 km and 40 km (6E-08 s/m^3, and 5E-09 s/m^3, respectively).

Because of the protective assumptions used in the DEL calculations, and the relatively low level of emissions, the most exposed member of the general public received far less than the calculated dose. This radiation dose may be compared with the individual natural radiation dose in the Point Lepreau area of approximately 2000 to 3000 μSv per annum. (TLDs show only the external, penetrating component, amounting to about 500 to 1000 μSv.) This includes natural dose contributions from ground, air, food and from an assumed low concentration of radon in homes. A significant fraction of Canadian homes contain radon levels that give a radiation dose much larger than this. In addition, the average annual medical radiation dose is about 350 μSv per person.

Table 6.01: Annual Dose

Source of Dose to Critical Group	*Dose to Critical Group (μSv/a)*
PLGS airborne emissions	0.35
PLGS liquid emissions	0.44
natural background (estimate)	2 000
average medical dose (estimate)	350

The only assessable radiation dose from PLGS to the local population is that from tritiated water vapour in air. This continues to be detected offsite in air and water samples.

7 Quality Assurance Results

The purpose of Quality Assurance is to provide confidence in the program and demonstrate that the program is able to meet its objectives. QA consists of the system whereby the laboratory can assure the regulator, NB Power, and the public that the laboratory is generating data of proven and known quality. It encompasses:

- personnel
- procedures
- measurements
- contamination
- records
- annual review
- program audits
- program improvement

This section describes how this was achieved for the year 2002. The specific procedures can be found in the *Quality Assurance* section of *Environmental Radiation Monitoring Program Procedures*[14].

7.01 Quality Control Checks

At the beginning of each day, the four main pieces of analytical equipment used in the OERMP have a quality control check performed on them. Key instrument parameters are checked and the results are compared against tolerance limits, and are also compared with previous results to detect trends in performance. To perform the quality control checks, radiation sources traceable to US or Canadian standards (National Institute of Standards and Technology and National Research Council) are used. Failures are investigated immediately.

The Quality Control (QC) evaluations in the laboratory cover the following instruments:

1. Canberra Intrinsic Ge Gamma Spectrometer
2. Beckman Liquid Scintillation Counter
3. Tennelec LB-5100 Gross Alpha/Beta Detector
4. Panasonic UD-710A TLD Reader

In the QC program, the operating parameters of each of the major instruments are evaluated at the start of each working day. (A background count is made each weekend to ensure the absence of contamination in the gamma spectrometer sample chamber.) This ensures that they are consistent and remain free from significant drift or random variation that could influence the analyses. A compilation of the results and statistical fluctuations is maintained, and from these data the upper and lower flag limits are determined. If any equipment exceeds these limits, it is not used for any analytical work until the problem has been resolved.

Throughout the year there were failures for each of the instruments. These failures involved only one of the seven to ten parameters monitored for each system. All of these failures were minor and were resolved on the same day they occurred.

Table 7.01: QC Passes & Failures

Instrument	*Number of Parameters Monitored Per Check*	*Number of Checks*	*Number of Checks Passed*	*Number of Individual Parameters Failed*	*Unresolved Failures*
Canberra Intrinsic Ge Gamma Spectrometer	7	251	244	10	0
Canberra Intrinsic Ge Gamma Spectrometer (Weekend Long Background)	8	50	48	7	0
Beckman Liquid Scintillation Counter	10	253	242	28	0
Tennelec LB-5100 Gross Alpha/Beta Detector	8	252	247	15	0
Panasonic UD-710A TLD Reader	8	249	243	12	0

7.01.01 Intrinsic Ge Gamma Spectrometer

A daily check of seven system parameters is performed for the germanium gamma spectroscopy system. Measurements are made of the energy centroids, full width half maxima (FWHM) and efficiencies of two widely separated photon energies of Eu-152. These show the accuracy and precision of the system relative to the defined limits of acceptance. The rate of liquid nitrogen consumption is monitored to verify the physical integrity of the cryostat. A computer program that generates QC plots and performs statistical tests to detect out-of-range values processes the results. A 200 000 s background count is made each weekend to ensure the absence of contamination in the sample chamber. The QC program evaluates the total counts in eight separate regions of the background spectrum, and out-of-range values are flagged for assessment.

The efficiency calibration of the gamma spectroscopy system is checked annually for each of the counting geometries. This is accomplished using a mixed nuclide standard traceable to the U.S. National Institute of Standards and Technology (NIST).

7.01.02 Beckman Liquid Scintillation Counter (model LS 6000TA)

A set of sealed tritium, C-14 and background standards traceable to NIST is analysed daily. Statistical parameters must lie within defined limits or the equipment will not be used. These same standards are used to calibrate the instrument for each analysis run.

7.01.03 Tennelec LB-5100 Gross Alpha/Beta Detector

Planchet standards of Am-241 and Sr-Y-90 are analysed daily. Alpha and Beta discrimination allows the simultaneous analysis of alpha and beta emissions on all samples analysed. Planchet and filter backgrounds are included in the QC checks. These same standards are used to calibrate the instrument for each analysis run.

7.01.04 Panasonic UD-710A TLD Reader

A set of 16 TLDs is exposed in the Panarad Irradiator and read out in the TLD reader. The mean of each of the four elements, dark current, reference light, reference element, and lamp flashes must all be within specified limits. The QA aspect of this system is covered in detail in *External Beta/Gamma Dosimetry Program*(13).

7.01.05 Other Instruments

Other instruments (balances, pipettes) are checked or calibrated at least annually. See the *Calibration, Maintenance and Repair* section of *Environmental Radiation Monitoring Program Procedures*(14). Frequencies of calibration are based on reproducibility of measurements and on time stability tests to ensure that the measurements made are within the specified tolerances for accuracy.

The gamma survey meters and contamination monitor are calibrated at PLGS on an annual basis.

7.02 External QA

The external quality assurance program consists of inter-comparisons with other laboratories, to give independent verification of analytical performance. The frequency of each program may vary at the discretion of the sponsoring agency (see Table 7.02). Four such groups – the International Atomic Energy Agency (IAEA), United States Department of Energy (USDOE), CANDU Owners Group (COG) and Analytics provide up to 10% of the sample load in the laboratory with blind or semi-blind samples. Results of our performance with these samples give an indication of the quality of measurements we are capable of producing.

This laboratory experienced numerous problems with its major supplier of QA samples in 2001. Early in 2002, a more dependable company was chosen.

The results are tabulated by radionuclide in Tables 7.03 and presented graphically in Figures 7.01 to 7.27. The same results are tabulated by medium in Tables 7.04 to 7.11. The tables show the sample date, while the figures show the analysis date.

The QA agent defines acceptable performance, generally in terms of an expected range. A failure signals the need to assess the procedures, analytical methods, or equipment calibrations.

There were 63 failures (out of 374 tests on 151 samples) in the external QA program:

- Alpha on Air Filter (NTS and Analytics) – There were six failures. Four of these were due to unclear instructions for preparation and counting from the supplier. One was a calibration or geometry difference between the calibration standard and QA sample, and one was a random failure.
- Beta on Air Filter (Analytics) – There were four failures due to unclear instructions for preparation and counting from the supplier.
- Cs-134 on Air Filter (Analytics) – There was one random failure.
- Sr-89 on Air Filter (Analytics) – There was one failure due to decay before analysis.
- Sr-90 on Air Filter (Analytics) – There was one random failure.
- Zn-65 on Air Filter (Analytics) – There was one random failure.
- I-131 on Charcoal Cartridge (Analytics) – There was one failure due to decay before analysis.
- Gamma Emitters on Charcoal Cartridge (NTS) – All five failures were in one charcoal cartridge. The QA supplier had deviated from the specified method of sample preparation.
- Alpha in Water (Analytics) – There was one random failure.
- Sr-89,90 in Water (NTS) – There were two failures for one sample. Lab personnel did not apply the correct volume.
- Gamma Emitters in Vegetation/Food (Analytics) – There were 18 failures. Three were random and 15 were due to geometry differences between the calibration standards and QA samples.
- Gamma Emitters in Soil (Analytics) – There were 22 failures. Two were random and 20 were due to geometry differences between the calibration standards and QA samples.

A COG project was undertaken in late 2001 and completed in 2002. Several Canadian laboratories took part in an intercomparison of sampling airborne tritium in the environment. Sampling equipment was sent to the Chalk River Laboratories where they were operated in parallel. The equipment was returned to each participating lab for processing. Results were comparable with a standard deviation of only about three percent of the mean.

Table 7.02: External Quality Assurance Frequency

Media	*Analyses*	*Number of QA Samples*	*External Agencies*
Filters	Gross Alpha/Beta	2	USDOE
		7	NTS/Analytics
	Gamma	2	USDOE
		7	NTS/Analytics
	Sr-89,90	2	USDOE
		4	NTS/Analytics
Charcoal Cartridges	Gamma	11	NTS/Analytics
Environmental Gamma	TLD	10	NRC
		no test in 2002	USDOE
Milk	Gamma	2	NTS/Analytics
Water	Gross Alpha/Beta	2	USDOE
		1	COG
		3	NTS/Analytics
	H-3	2	NTS/Analytics
		4	NTS/Analytics
	C-14	4	COG
		1	NTS/Analytics
	Gamma	2	USDOE
		2	COG
		5	NTS/Analytics
	Sr-89,90	2	USDOE
		1	NTS/Analytics
Food/Vegetation	Gamma	2	USDOE
		10	NTS/Analytics
Soil/Sediment	Gamma	2	USDOE
		6	NTS/Analytics
Urine	H-3	30	RPB
	C-14	20	RPB
	Gamma	4	RPB

Table 7.03: Comparison of QA Agent, All Participants and NB Power

Analysis	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
ALPHA (Figure 7.01)	7.04	2002/06/13	0.27 Fail	
	7.04	2002/06/13	0.29 Fail	
	7.04	2002/09/12	0.04 Fail	
	7.04	2002/09/12	0.10 Fail	
	7.04	2002/12/05	0.86 Fail	
	7.04	2002/12/05	0.89	
	7.08	2002/06/13	1.27 Fail	
	7.08	2002/12/05	0.91	
	7.04	2002/03/01	0.90	0.79 - 1.32
	7.04	2002/09/01	0.89	0.77 - 1.33
	7.08	2002/03/01	0.81	0.70 - 1.26
	7.08	2002/09/01	0.93	0.76 - 1.31
	7.04	2002/02/18	2.16 Fail	
	7.08	2002/02/18	0.82	
BETA (Figure 7.02)	7.04	2002/06/13	0.18 Fail	
	7.04	2002/06/13	0.24 Fail	
	7.04	2002/09/12	0.10 Fail	
	7.04	2002/09/12	0.38 Fail	
	7.04	2002/12/05	0.96	
	7.04	2002/12/05	0.96	
	7.08	2002/06/13	1.05	
	7.08	2002/12/05	1.08	
	7.04	2002/05/01	0.99	0.47 - 1.84
	7.04	2002/03/01	0.92	0.78 - 1.18
	7.04	2002/09/01	0.86	0.73 - 1.11
	7.08	2002/03/01	0.90	0.73 - 1.19
	7.08	2002/09/01	0.93	0.74 - 1.18
	7.04	2002/02/18	1.05	
	7.08	2002/02/18	1.22	
Am-241 (Figure 7.03)	7.04	2002/02/18	1.32	
Ba-133 (Figure 7.04)	7.04	2002/02/18	1.03	
	7.05	2002/02/18	0.53 Fail	
	7.08	2002/02/18	1.10	
	7.09	2002/02/18	1.09	
	7.11	2002/09/01	1.07	0.85 - 1.17

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
C-14 (Figure 7.05)	7.08	2002/05/01	0.91	0.56 - 1.29
	7.08	2002/08/01	0.86	0.77 - 1.12
	7.08	2002/05/01	0.90	0.52 - 1.37
	7.08	2002/08/01	0.87	0.78 - 1.16
	7.08	2002/02/18	0.93	
	7.11	2002/05/16	0.91	0.89 - 1.04
	7.11	2002/05/16	0.94	0.83 - 1.11
	7.11	2002/05/16	0.93	0.91 - 1.06
Cd-109 (Figure 7.06)	7.08	2002/05/01	1.03	0.88 - 1.08
	7.08	2002/08/01	0.99	0.91 - 1.12
Ce-139 (Figure 7.07)	7.08	2002/05/01	1.07	0.96 - 1.09
	7.08	2002/08/01	1.02	0.96 - 1.06
	7.04	2002/02/18	0.95	
	7.05	2002/02/18	0.45 Fail	
	7.09	2002/02/18	0.93	
	7.08	2002/02/18	1.16	
Ce-141 (Figure 7.08)	7.04	2002/06/13	1.13	
	7.04	2002/06/13	1.27	
	7.04	2002/09/12	0.93	
	7.04	2002/09/12	1.00	
	7.04	2002/12/05	1.01	
	7.04	2002/12/05	1.01	
	7.09	2002/12/05	1.31 Fail	
	7.09	2002/12/05	1.36 Fail	
	7.09	2002/12/05	1.35 Fail	
	7.07	2002/06/13	1.01	
	7.07	2002/12/05	1.06	
	7.10	2002/09/12	1.14	
	7.10	2002/09/12	1.18	
	7.10	2002/12/05	0.90	
	7.10	2002/12/05	0.93	
	7.09	2002/09/12	1.23	
	7.09	2002/09/12	1.16	
	7.09	2002/09/12	0.94	
	7.08	2002/06/13	1.03	
	7.08	2002/06/13	1.05	
	7.08	2002/09/12	1.00	
	7.08	2002/09/12	1.01	
	7.08	2002/12/05	1.01	

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Co-57 (Figure 7.09)	7.08	2002/05/01	1.04	0.89 - 1.12
	7.08	2002/08/01	1.02	0.95 - 1.06
Co-58 (Figure 7.10)	7.04	2002/06/13	1.16	
	7.04	2002/06/13	1.22	
	7.04	2002/09/12	1.04	
	7.04	2002/09/12	1.00	
	7.04	2002/12/05	1.13	
	7.04	2002/12/05	1.04	
	7.09	2002/12/05	1.18	
	7.09	2002/12/05	1.24 Fail	
	7.09	2002/12/05	1.19	
	7.07	2002/06/13	1.00	
	7.07	2002/12/05	0.99	
	7.10	2002/09/12	1.37 Fail	
	7.10	2002/09/12	1.42 Fail	
	7.10	2002/12/05	0.86	
	7.10	2002/12/05	1.00	
	7.09	2002/06/13	1.26	
	7.09	2002/06/13	1.06	
	7.09	2002/06/13	1.28	
	7.09	2002/09/12	1.20	
	7.09	2002/09/12	1.08	
	7.09	2002/09/12	0.95	
	7.08	2002/06/13	1.03	
	7.08	2002/06/13	0.99	
	7.08	2002/09/12	1.05	
	7.08	2002/09/12	1.03	
	7.08	2002/12/05	0.97	
Co-60 (Figure 7.11)	7.04	2002/06/13	1.01	
	7.04	2002/06/13	1.06	
	7.04	2002/09/12	0.94	
	7.04	2002/09/12	0.96	
	7.04	2002/12/05	1.03	
	7.04	2002/12/05	0.98	
	7.09	2002/12/05	1.18 Fail	
	7.09	2002/12/05	1.18 Fail	
	7.09	2002/12/05	1.20 Fail	
	7.07	2002/06/13	1.01	
	7.07	2002/12/05	0.99	
	7.10	2002/06/13	1.30 Fail	

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Co-60 (Figure 7.11) continued	7.10	2002/06/13	1.32 Fail	
	7.10	2002/09/12	1.16	
	7.10	2002/09/12	1.20	
	7.10	2002/12/05	0.76 Fail	
	7.10	2002/12/05	0.85	
	7.09	2002/06/13	1.02	
	7.09	2002/06/13	1.08	
	7.09	2002/06/13	1.08	
	7.09	2002/09/12	1.23 Fail	
	7.09	2002/09/12	1.03	
	7.09	2002/09/12	0.81 Fail	
	7.08	2002/06/13	1.01	
	7.08	2002/06/13	1.00	
	7.08	2002/09/12	0.98	
	7.08	2002/09/12	0.98	
	7.08	2002/12/05	1.01	
	7.08	2002/05/01	1.01	0.91 - 1.09
	7.08	2002/08/01	0.99	0.95 - 1.05
	7.04	2002/03/01	0.95	0.90 - 1.12
	7.04	2002/09/01	0.99	0.87 - 1.16
	7.09	2002/03/01	1.25	0.80 - 1.36
	7.09	2002/09/01	0.99	0.82 - 1.27
	7.08	2002/03/01	0.92	0.93 - 1.11
	7.08	2002/09/01	0.94	0.92 - 1.13
	7.04	2002/02/18	1.01	
	7.05	2002/02/18	0.57 Fail	
	7.09	2002/02/18	0.96	
	7.08	2002/02/18	1.02	
	7.11	2002/09/01	0.97	0.93 - 1.09
Cr-51 (Figure 7.12)	7.04	2002/06/13	0.98	
	7.04	2002/09/12	1.05	
	7.04	2002/09/12	1.26	
	7.04	2002/12/05	1.07	
	7.04	2002/12/05	1.08	
	7.09	2002/12/05	1.52 Fail	
	7.09	2002/12/05	1.43 Fail	
	7.09	2002/12/05	1.38 Fail	
	7.07	2002/06/13	1.00	
	7.07	2002/12/05	1.08	
	7.10	2002/09/12	1.45	
	7.10	2002/12/05	0.88	

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Cr-51 (Figure 7.12) continued	7.10	2002/12/05	1.02	
	7.09	2002/09/12	1.46	
	7.08	2002/06/13	0.97	
	7.08	2002/06/13	1.07	
	7.08	2002/09/12	1.03	
	7.08	2002/09/12	1.14	
	7.08	2002/12/05	1.02	
Cs-134 (Figure 7.13)	7.04	2002/06/13	0.81	
	7.04	2002/06/13	1.01	
	7.04	2002/09/12	0.98	
	7.04	2002/09/12	0.85 Fail	
	7.04	2002/12/05	0.92	
	7.04	2002/12/05	1.01	
	7.09	2002/12/05	1.18	
	7.09	2002/12/05	1.15	
	7.09	2002/12/05	1.14	
	7.07	2002/06/13	1.01	
	7.07	2002/12/05	1.06	
	7.10	2002/06/13	1.40 Fail	
	7.10	2002/06/13	1.49 Fail	
	7.10	2002/09/12	1.36 Fail	
	7.10	2002/09/12	1.27 Fail	
	7.10	2002/12/05	0.75 Fail	
	7.10	2002/12/05	0.84	
	7.09	2002/06/13	1.06	
	7.09	2002/06/13	1.07	
	7.09	2002/06/13	1.02	
	7.09	2002/09/12	1.24 Fail	
	7.09	2002/09/12	1.04	
	7.09	2002/09/12	0.85	
	7.08	2002/06/13	1.11	
	7.08	2002/06/13	1.00	
	7.08	2002/09/12	1.09	
	7.08	2002/09/12	1.00	
	7.08	2002/12/05	0.92	
	7.08	2002/09/01	1.16	0.83 - 1.13

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Cs-137 (Figure 7.14)	7.04	2002/06/13	1.01	
	7.04	2002/06/13	1.07	
	7.04	2002/09/12	0.92	
	7.04	2002/09/12	0.99	
	7.04	2002/12/05	1.05	
	7.04	2002/12/05	1.03	
	7.09	2002/12/05	1.14	
	7.09	2002/12/05	1.15	
	7.09	2002/12/05	1.25 Fail	
	7.07	2002/06/13	0.93	
	7.07	2002/12/05	0.96	
	7.10	2002/06/13	1.50 Fail	
	7.10	2002/06/13	1.62 Fail	
	7.10	2002/09/12	1.43 Fail	
	7.10	2002/09/12	1.38 Fail	
	7.10	2002/12/05	0.94	
	7.10	2002/12/05	0.90	
	7.09	2002/06/13	1.01	
	7.09	2002/06/13	1.10	
	7.09	2002/06/13	1.12	
	7.09	2002/09/12	1.20	
	7.09	2002/09/12	1.03	
	7.09	2002/09/12	0.91	
	7.08	2002/06/13	0.96	
	7.08	2002/06/13	0.97	
	7.08	2002/09/12	0.97	
	7.08	2002/09/12	0.98	
	7.08	2002/12/05	1.01	
	7.08	2002/05/01	0.97	0.94 - 1.06
	7.08	2002/08/01	0.97	0.95 - 1.05
	7.04	2002/03/01	0.99	0.91 - 1.20
	7.04	2002/09/01	0.98	0.86 - 1.23
	7.10	2002/03/01	0.88	0.84 - 1.14
	7.10	2002/09/01	0.92	0.85 - 1.17
	7.09	2002/03/01	1.15	0.86 - 1.24
	7.09	2002/09/01	1.09	0.85 - 1.23
	7.08	2002/03/01	0.93	0.90 - 1.15
	7.08	2002/09/01	1.00	0.92 - 1.14
	7.04	2002/02/18	0.99	
	7.05	2002/02/18	0.52 Fail	
	7.09	2002/02/18	0.89	
	7.08	2002/02/18	0.94	
	7.11	2002/09/01	0.93	0.88 - 1.14

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Fe-59 (Figure 7.15)	7.04	2002/06/13	1.17	
	7.04	2002/06/13	1.19	
	7.04	2002/09/12	1.00	
	7.04	2002/09/12	1.08	
	7.04	2002/12/05	1.02	
	7.04	2002/12/05	1.16	
	7.09	2002/12/05	1.42	
	7.09	2002/12/05	1.33	
	7.09	2002/12/05	0.87	
	7.07	2002/06/13	1.13	
	7.07	2002/12/05	1.07	
	7.10	2002/09/12	1.31	
	7.10	2002/09/12	1.30	
	7.10	2002/12/05	1.00	
	7.10	2002/12/05	0.87	
	7.09	2002/09/12	1.33	
	7.09	2002/09/12	1.01	
	7.09	2002/09/12	0.84	
	7.08	2002/06/13	1.04	
	7.08	2002/06/13	1.04	
	7.08	2002/09/12	1.08	
	7.08	2002/09/12	1.08	
	7.08	2002/12/05	1.12	
Gamma (Figure 7.16)	7.06	2002/07/29	0.95	
H-3 (Figure 7.17)	7.08	2002/06/13	0.91	
	7.08	2002/05/01	0.95	0.94 - 1.04
	7.08	2002/08/01	0.94	0.90 - 1.08
	7.08	2002/05/01	0.98	0.56 - 1.75
	7.08	2002/08/01	0.96	0.72 - 1.45
	7.08	2002/03/01	0.92	0.67 - 1.43
	7.08	2002/09/01	1.02	0.82 - 1.35
	7.08	2002/02/18	0.86	
	7.11	2002/04/18	0.82	0.70 - 1.21
	7.11	2002/04/18	0.91	0.75 - 1.24
	7.11	2002/04/18	0.91	0.74 - 1.26

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Hg-203 (Figure 7.18)	7.08	2002/05/01	1.00	0.93 - 1.09
	7.08	2002/08/01	1.03	0.93 - 1.11
I-131 (Figure 7.19)	7.05	2002/07/25	0.87	
	7.05	2002/07/25	1.11	
	7.05	2002/07/25	0.71 Fail	
	7.05	2002/09/12	0.95	
	7.05	2002/09/12	0.89	
	7.05	2002/09/12	0.90	
	7.05	2002/12/05	0.95	
	7.05	2002/12/05	0.94	
	7.05	2002/12/05	0.95	
	7.05	2002/12/05	1.03	
	7.07	2002/06/13	1.08	
	7.07	2002/12/05	1.10	
	7.08	2002/06/13	1.12	
	7.08	2002/06/13	1.02	
	7.08	2002/09/12	1.09	
	7.08	2002/09/12	1.03	
	7.08	2002/12/05	1.18	
K-40 (Figure 7.20)	7.10	2002/03/01	0.91	0.82 - 1.13
	7.10	2002/09/01	0.92	0.84 - 1.20
	7.09	2002/03/01	1.12	0.87 - 1.26
	7.09	2002/09/01	1.08	0.83 - 1.24
Mn-54 (Figure 7.21)	7.04	2002/06/13	1.16	
	7.04	2002/06/13	1.15	
	7.04	2002/09/12	1.05	
	7.04	2002/09/12	1.12	
	7.04	2002/12/05	1.15	
	7.04	2002/12/05	1.16	
	7.09	2002/12/05	1.24 Fail	
	7.09	2002/12/05	1.29 Fail	
	7.09	2002/12/05	1.30 Fail	
	7.07	2002/06/13	1.07	
	7.07	2002/12/05	1.03	
	7.10	2002/06/13	1.47 Fail	
	7.10	2002/06/13	1.63 Fail	
	7.10	2002/09/12	1.42 Fail	
	7.10	2002/09/12	1.33 Fail	
	7.10	2002/12/05	0.92	

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Mn-54 (Figure 7.21) continued	7.10	2002/12/05	0.96	
	7.09	2002/06/13	1.09	
	7.09	2002/06/13	1.20	
	7.09	2002/06/13	1.21	
	7.09	2002/09/12	1.07	
	7.09	2002/09/12	1.12	
	7.09	2002/09/12	0.89	
	7.08	2002/06/13	1.08	
	7.08	2002/06/13	1.05	
	7.08	2002/09/12	1.04	
	7.08	2002/09/12	1.04	
	7.08	2002/12/05	1.01	
	7.04	2002/03/01	1.01	0.90 - 1.19
	7.04	2002/09/01	0.98	0.80 - 1.18
	7.04	2002/02/18	1.05	
	7.05	2002/02/18	0.53 Fail	
	7.09	2002/02/18	0.95	
	7.08	2002/02/18	0.93	
Sn-113 (Figure 7.22)	7.08	2002/05/01	1.05	0.91 - 1.08
	7.08	2002/08/01	1.09	0.90 - 1.07
Sr-85 (Figure 7.23)	7.08	2002/05/01	0.99	0.95 - 1.06
	7.08	2002/08/01	1.06	0.95 - 1.10
Sr-89 (Figure 7.24)	7.04	2002/06/13	0.68 Fail	
	7.04	2002/09/12	0.99	
	7.04	2002/12/05	0.93	
	7.04	2002/02/18	0.99	
	7.08	2002/02/18	0.26 Fail	
Sr-90 (Figure 7.25)	7.04	2002/06/13	0.92	
	7.04	2002/09/12	0.82 Fail	
	7.04	2002/12/05	0.92	
	7.08	2002/03/01	0.75	0.67 - 1.19
	7.04	2002/09/01	0.90	0.60 - 1.42
	7.04	2002/03/01	0.75	0.70 - 1.14
	7.08	2002/09/01	0.85	0.77 - 1.15
	7.04	2002/02/18	1.01	
	7.08	2002/02/18	0.25 Fail	
Y-88 (Figure 7.26)	7.08	2002/05/01	1.02	0.95 - 1.03
	7.08	2002/08/01	1.02	0.94 - 1.06

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Zn-65 (Figure 7.27)	7.04	2002/06/13	1.16	
	7.04	2002/06/13	1.23 Fail	
	7.04	2002/09/12	1.12	
	7.04	2002/09/12	1.20	
	7.04	2002/12/05	1.18	
	7.04	2002/12/05	1.20	
	7.09	2002/12/05	1.18	
	7.09	2002/12/05	1.31 Fail	
	7.09	2002/12/05	1.27	
	7.07	2002/06/13	1.03	
	7.07	2002/12/05	1.02	
	7.10	2002/06/13	1.49 Fail	
	7.10	2002/06/13	1.49 Fail	
	7.10	2002/09/12	1.40 Fail	
	7.10	2002/09/12	1.35 Fail	
	7.10	2002/12/05	1.05	
	7.10	2002/12/05	1.03	
	7.09	2002/06/13	1.15	
	7.09	2002/06/13	1.22	
	7.09	2002/06/13	1.14	
	7.09	2002/09/12	1.18	
	7.09	2002/09/12	1.09	
	7.09	2002/09/12	0.99	
	7.08	2002/06/13	1.02	
	7.08	2002/06/13	1.07	
	7.08	2002/09/12	1.05	
	7.08	2002/09/12	1.08	
	7.08	2002/12/05	1.05	

Table 7.04: Air Filter

Analysis	Sample Date	QA Agent	NB Power (pCi/filter ± 2 sigma)	NB Power/ QA Agent (ratio)
ALPHA	2002-06-13	27 ± 2	7.2 ± 0.5	0.27 Fail
	2002-06-13	23 ± 2	6.8 ± 0.5	0.29 Fail
	2002-09-12	70 ± 5	2.9 ± 0.3	0.04 Fail
	2002-09-12	92 ± 6	8.8 ± 0.6	0.10 Fail
	2002-12-05	54 ± 4	47 ± 2	0.86 Fail
	2002-12-05	43 ± 3	38 ± 2	0.89
	2002-03-01	14 ± 1	13 ± 0.8	0.90
	2002-09-01	8 ± 1	6.9 ± 0.5	0.89
	2002-02-18	58 ± 8	126 ± 12	2.16 Fail
BETA	2002-06-13	188 ± 12	33 ± 1	0.18 Fail
	2002-06-13	163 ± 11	39 ± 1	0.24 Fail
	2002-09-12	181 ± 12	18 ± 1	0.10 Fail
	2002-09-12	242 ± 16	93 ± 3	0.38 Fail
	2002-12-05	137 ± 9	131 ± 4	0.96
	2002-12-05	110 ± 7	106 ± 3	0.96
	2002-03-01	35 ± 3	32 ± 2.7	0.92
	2002-09-01	24 ± 2	20 ± 0.9	0.86
	2002-05-01	1305 ± 326	1291 ± 36	0.99
	2002-02-18	3910 ± 400	4110 ± 115	1.05
Am-241	2002-02-18	58 ± 7	77 ± 12	1.32
Ba-133	2002-02-18	436 ± 45	451 ± 30	1.03
Ce-139	2002-02-18	19 ± 2	18 ± 2	0.95
Ce-141	2002-06-13	86 ± 6	98 ± 11	1.13
	2002-06-13	72 ± 5	91 ± 12	1.27
	2002-09-12	120 ± 8	111 ± 8	0.93
	2002-09-12	96 ± 6	96 ± 7	1.00
	2002-12-05	95 ± 6	96 ± 7	1.01
	2002-12-05	68 ± 4	69 ± 5	1.01
Co-58	2002-06-13	96 ± 6	111 ± 10	1.16
	2002-06-13	76 ± 5	93 ± 10	1.22
	2002-09-12	73 ± 5	76 ± 7	1.04
	2002-09-12	58 ± 4	58 ± 6	1.00
	2002-12-05	118 ± 8	133 ± 10	1.13
	2002-12-05	85 ± 6	88 ± 7	1.04

Table 7.04 (continued): Air Filter

Analysis	Sample Date	QA Agent	NB Power (pCi/filter ± 2 sigma)	NB Power/ QA Agent (ratio)
Co-60	2002-06-13	120 ± 8	121 ± 7	1.01
	2002-06-13	100 ± 7	106 ± 6	1.06
	2002-09-12	111 ± 7	104 ± 6	0.94
	2002-09-12	89 ± 6	85 ± 5	0.96
	2002-12-05	140 ± 9	144 ± 8	1.03
	2002-12-05	101 ± 7	99 ± 6	0.98
	2002-03-01	999 ± 27	783 ± 1	0.95
	2002-09-01	621 ± 0	621 ± 27	0.99
	2002-02-18	432 ± 45	436 ± 20	1.01
Cr-51	2002-06-13	226 ± 15	222 ± 7	0.98
	2002-09-12	170 ± 11	179 ± 25	1.05
	2002-09-12	136 ± 9	172 ± 24	1.26
	2002-12-05	296 ± 19	318 ±30	1.07
	2002-12-05	213 ± 14	231 ± 26	1.08
Cs-134	2002-06-13	116 ± 8	94 ± 17	0.81
	2002-06-13	97 ± 6	98 ± 12	1.01
	2002-09-12	99 ± 6	97 ± 14	0.98
	2002-09-12	79 ± 5	67 ± 5	0.85 Fail
	2002-12-05	85 ± 6	78 ± 6	0.92
	2002-12-05	61 ± 4	62 ± 9	1.01
Cs-137	2002-06-13	88 ± 6	89 ± 7	1.01
	2002-06-13	73 ± 5	78 ± 6	1.07
	2002-09-12	95 ± 6	87 ± 7	0.92
	2002-09-12	76 ± 5	75 ± 6	0.99
	2002-12-05	188 ± 12	198 ± 13	1.05
	2002-12-05	135 ± 9	139 ± 10	1.03
	2002-03-01	756 ± 27	756 ± 54	0.99
	2002-09-01	891 ± 27	864 ± 54	0.98
	2002-02-18	3480 ± 360	3430 ± 197	0.99
Fe-59	2002-06-13	77 ± 5	90 ± 21	1.17
	2002-06-13	65 ± 4	78 ± 22	1.19
	2002-09-12	66 ± 4	66 ± 11	1.00
	2002-09-12	53 ± 3	57 ± 11	1.08
	2002-12-05	62 ± 4	64 ± 10	1.02
	2002-12-05	44 ± 3	51 ± 9	1.16

Table 7.04 (continued): Air Filter

Analysis	Sample Date	QA Agent	NB Power (pCi/filter ± 2 sigma)	NB Power/ QA Agent (ratio)
Mn-54	2002-06-13	91 ± 6	106 ± 9	1.16
	2002-06-13	80 ± 5	92 ± 8	1.15
	2002-09-12	114 ± 7	120 ± 9	1.05
	2002-09-12	91 ± 6	102 ± 8	1.12
	2002-12-05	121 ± 8	139 ± 10	1.15
	2002-12-05	87 ± 6	101 ± 8	1.16
	2002-03-01	1053 ± 27	1053 ± 154	1.01
	2002-09-01	1485 ± 27	1458 ± 181	0.98
	2002-02-18	57 ± 6	60 ± 6	1.05
Sr-89	2002-06-13	50 ± 3	34 ± 2	0.68 Fail
	2002-09-12	72 ± 5	72 ± 4	0.99
	2002-12-05	102 ± 7	94 ± 5	0.93
	2002-02-18	39 ± 4	39 ± 1	0.99
Sr-90	2002-06-13	76 ± 5	70 ± 4	0.92
	2002-09-12	38 ± 2	31 ± 2	0.82 Fail
	2002-12-05	66 ± 4	60 ± 3	0.92
	2002-03-01	130 ± 5	97 ± 2.7	0.75
	2002-09-01	151 ± 3	135 ± 2.7	0.90
	2002-02-18	70 ± 7	71 ± 2	1.01
Zn-65	2002-06-13	172 ± 11	200 ± 18	1.16
	2002-06-13	144 ± 9	177 ± 17	1.23 Fail
	2002-09-12	141 ± 9	158 ± 15	1.12
	2002-09-12	113 ± 7	136 ± 13	1.20
	2002-12-05	153 ± 10	181 ± 16	1.18
	2002-12-05	110 ± 7	132 ± 13	1.20

Table 7.05: Charcoal Cartridge

Analysis	Sample Date	QA Agent	NB Power (pCi/cartridge ± 2 sigma)	NB Power/QA Agent (ratio)
Ba-133	2002-02-18	611 ± 70	322 ± 34	0.53 Fail
Ce-139	2002-02-18	27 ± 3	12 ± 3	0.45 Fail
Co-60	2002-02-18	605 ± 60	343 ± 18	0.57 Fail
Cs-137	2002-02-18	4870 ± 500	2520 ± 147	0.52 Fail
I-131	2002-07-25	84 ± 5	73 ± 7	0.87
	2002-07-25	80 ± 5	89 ± 10	1.11
	2002-07-25	95 ± 6	68 ± 12	0.71 Fail
	2002-09-12	81 ± 5	77 ± 20	0.95
	2002-09-12	70 ± 5	62 ± 22	0.89
	2002-09-12	90 ± 6	81 ± 15	0.90
	2002-12-05	84 ± 5	80 ± 11	0.95
	2002-12-05	87 ± 6	82 ± 13	0.94
	2002-12-05	92 ± 6	87 ± 23	0.95
	2002-12-05	94 ± 6	97 ± 19	1.03
Mn-54	2002-02-18	79 ± 8	42 ± 6	0.53 Fail

Table 7.06: Environmental TLD

Analysis	Sample Date	QA Agent	NB Power (mR ± 2 sigma)	NB Power/QA Agent (ratio)
GAMMA	2002-08-27	126 ± 0	120 ± 6	0.95

Table 7.07: Milk

Analysis	Sample Date	QA Agent	NB Power (pCi/L ± 2 sigma)	NB Power/ QA Agent (ratio)
Ce-141	2002-06-13	90 ± 6	91 ± 7	1.01
	2002-12-05	111 ± 7	118 ± 9	1.06
Co-58	2002-06-13	100 ± 7	100 ± 7	1.00
	2002-12-05	139 ± 9	137 ± 10	0.99
Co-60	2002-06-13	125 ± 8	126 ± 7	1.01
	2002-12-05	164 ± 11	163 ± 8	0.99
Cr-51	2002-06-13	235 ± 15	235 ± 25	1.00
	2002-12-05	346 ± 23	375 ± 35	1.08
Cs-134	2002-06-13	120 ± 8	121 ± 13	1.01
	2002-12-05	99 ± 6	105 ± 13	1.06
Cs-137	2002-06-13	91 ± 6	85 ± 6	0.93
	2002-12-05	220 ± 14	212 ± 14	0.96
Fe-59	2002-06-13	81 ± 5	92 ± 10	1.13
	2002-12-05	72 ± 5	77 ± 9	1.07
I-131	2002-06-13	87 ± 6	94 ± 10	1.08
	2002-12-05	86 ± 6	94 ± 10	1.10
Mn-54	2002-06-13	95 ± 6	102 ± 7	1.07
	2002-12-05	142 ± 9	146 ± 10	1.03
Zn-65	2002-06-13	180 ± 12	186 ± 14	1.03
	2002-12-05	178 ± 12	182 ± 14	1.02

Table 7.08: Water

Analysis	Sample Date	QA Agent	NB Power (pCi/L ± 2 sigma)	NB Power/ QA Agent (ratio)
ALPHA	2002-06-13	40 ± 3	51 ± 2	1.27 Fail
	2002-12-05	84 ± 5	76 ± 5	0.91
	2002-03-01	10125 ± 1026	8181 ± 648	0.81
	2002-09-01	5670 ± 567	5292 ± 486	0.93
	2002-02-18	59 ± 9	48 ± 3	0.82
BETA	2002-06-13	280 ± 18	293 ± 6	1.05
	2002-12-05	216 ± 14	233 ± 10	1.08
	2002-03-01	27810 ± 2781	25110 ± 1404	0.90
	2002-09-01	24300 ± 2430	22707 ± 1296	0.93
	2002-02-18	58 ± 9	71 ± 4	1.22
Ba-133	2002-02-18	872 ± 90	955 ± 112	1.10

Table 7.08 (continued): Water

Analysis	Sample Date	QA Agent	NB Power (pCi/L ± 2 sigma)	NB Power/ QA Agent (ratio)
C-14	2002-05-01	1.2E7 ± 2E6	1.1E7 ± 0	0.90
	2002-05-01	1.61E8 ± 4E6	1.47E8 ± 4E6	0.91
	2002-08-01	3.2E6 ± 5E5	2.7E6 ± 1E5	0.87
	2002-08-01	2.16E8 ± 3.2E7	1.85E8 ± 4E6	0.86
	2002-02-18	1060 ± 127	991 ± 122	0.93
Cd-109	2002-05-01	4.6E7 ± 7E6	4.8E7 ± 3E6	1.03
	2002-08-01	4.7E7 ± 7E6	4.7E7 ± 3E6	0.99
Ce-139	2002-05-01	2.3E6 ± 3E5	2.4E6 ± 1E5	1.07
	2002-08-01	2.5E6 ± 4E5	2.5E6 ± 2E5	1.02
	2002-02-18	38 ± 5	44 ± 9	1.16
Ce-141	2002-06-13	83 ± 5	85 ± 7	1.03
	2002-06-13	83 ± 5	87 ± 7	1.05
	2002-09-12	214 ± 14	214 ± 14	1.00
	2002-09-12	214 ± 14	216 ± 14	1.01
	2002-12-05	106 ± 7	107 ± 8	1.01
Co-57	2002-05-01	1.9E6 ± 3E5	1.9E6 ± 1E5	1.04
	2002-08-01	1.9E6 ± 3E5	1.9E6 ± 1E5	1.02
Co-58	2002-06-13	93 ± 6	96 ± 7	1.03
	2002-06-13	93 ± 6	92 ± 7	0.99
	2002-09-12	130 ± 8	136 ± 10	1.05
	2002-09-12	130 ± 8	134 ± 9	1.03
	2002-12-05	133 ± 9	129 ± 9	0.97
Co-60	2002-06-13	115 ± 8	116 ± 6	1.01
	2002-06-13	115 ± 8	115 ± 6	1.00
	2002-09-12	199 ± 13	196 ± 10	0.98
	2002-09-12	199 ± 13	195 ± 10	0.98
	2002-12-05	157 ± 10	158 ± 8	1.01
	2002-03-01	9369 ± 324	8613 ± 405	0.92
	2002-09-01	7263 ± 270	6804 ± 324	0.94
	2002-05-01	9.1E6 ± 1.4E6	9.3E6 ± 4E5	1.01
	2002-08-01	9.4E6 ± 1.4E6	9.4E6 ± 4E5	0.99
	2002-02-18	865 ± 92	879 ± 62	1.02
Cr-51	2002-06-13	218 ± 14	211 ± 27	0.97
	2002-06-13	[illegible]18 ± 14	233 ± 32	1.07
	2002-09-12	30[illegible] ± 20	313 ± 29	1.03
	2002-09-12	304 ± 20	348 ± 31	1.14
	2002-12-05	331 ± 22	338 ± 35	1.02

Table 7.08 (continued): Water

Analysis	Sample Date	QA Agent	NB Power (pCi/L ± 2 sigma)	NB Power/ QA Agent (ratio)
Cs-134	2002-06-13	111 ± 7	123 ± 13	1.11
	2002-06-13	111 ± 7	111 ± 12	1.00
	2002-09-12	176 ± 12	192 ± 18	1.09
	2002-09-12	176 ± 12	175 ± 18	1.00
	2002-12-05	95 ± 6	87 ± 10	0.92
	2002-09-01	1620 ± 54	1890 ± 243	1.16
Cs-137	2002-06-13	84 ± 5	81 ± 6	0.96
	2002-06-13	84 ± 5	82 ± 6	0.97
	2002-09-12	169 ± 11	164 ± 11	0.97
	2002-09-12	169 ± 11	165 ± 11	0.98
	2002-12-05	210 ± 14	212 ± 14	1.01
	2002-03-01	1512 ± 81	1404 ± 108	0.93
	2002-09-01	2187 ± 108	2187 ± 162	1.00
	2002-05-01	8E6 ± 1.2E6	7.8E6 ± 5E5	0.97
	2002-08-01	8.1E6 ± 1.2E6	7.9E6 ± 5E5	0.97
	2002-02-18	6960 ± 720	6540 ± 511	0.94
Fe-59	2002-06-13	75 ± 5	78 ± 9	1.04
	2002-06-13	75 ± 5	78 ± 10	1.04
	2002-09-12	119 ± 8	128 ± 11	1.08
	2002-09-12	119 ± 8	129 ± 12	1.08
	2002-12-05	69 ± 5	77 ± 9	1.12
H-3	2002-06-13	6970 ± 455	6330 ± 219	0.91
	2002-03-01	7668 ± 81	7074 ± 297	0.92
	2002-09-01	6129 ± 162	6237 ± 270	1.02
	2002-05-01	2.7E6 ± 4E5	2.7E6 ± 1E5	0.98
	2002-05-02	1.81E8 ± 2.7E7	1.72E8 ± 4E6	0.95
	2002-08-01	2.8E6 ± 4E5	2.6E6 ± 1E5	0.96
	2002-08-02	2.2E8 ± 3.3E7	2.06E8 ± 5E6	0.94
	2002-02-18	3420 ± 410	2930 ± 226	0.86
Hg-203	2002-05-01	6.5E6 ± 1E6	6.4E6 ± 4E5	1.00
	2002-08-01	6.6E6 ± 1E6	6.8E6 ± 4E5	1.03
I-131	2002-06-13	94 ± 6	105 ± 17	1.12
	2002-06-13	94 ± 6	96 ± 20	1.02
	2002-09-12	79 ± 5	86 ± 8	1.09
	2002-09-12	79 ± 5	82 ± 9	1.03
	2002-12-05	94 ± 6	111 ± 20	1.18

Table 7.08 (continued): Water

Analysis	Sample Date	QA Agent	NB Power (pCi/L ± 2 sigma)	NB Power/ QA Agent (ratio)
Mn-54	2002-06-13	88 ± 6	95 ± 7	1.08
	2002-06-13	88 ± 6	92 ± 7	1.05
	2002-09-12	204 ± 13	213 ± 14	1.04
	2002-09-12	204 ± 13	213 ± 14	1.04
	2002-12-05	136 ± 9	137 ± 10	1.01
	2002-02-18	113 ± 13	105 ± 16	0.93
Sn-113	2002-05-01	9E6 ± 1.4E6	9.4E6 ± 5E5	1.05
	2002-08-01	9E6 ± 1.4E6	9.8E6 ± 5E5	1.09
Sr-85	2002-05-01	1.1E7 ± 2E6	1.1E7 ± 1E6	0.99
	2002-08-01	1.1E7 ± 2E6	1.2E7 ± 1E6	1.06
Sr-89	2002-02-18	42 ± 6	11 ± 1	0.26 Fail
Sr-90	2002-03-01	205 ± 5.4	154 ± 10.8	0.75
	2002-09-01	235 ± 10.8	200 ± 10.8	0.85
	2002-02-18	87 ± 10	22 ± 1	0.25 Fail
Y-88	2002-05-01	1.8E7± 3E6	1.9E7 ± 1E6	1.02
	2002-08-01	1.9E7± 3E6	1.9E7 ± 1E6	1.02
Zn-65	2002-06-13	166 ± 11	169 ± 13	1.02
	2002-06-13	166 ± 11	177 ± 14	1.07
	2002-09-12	251 ± 16	263 ± 19	1.05
	2002-09-12	251 ± 16	271 ± 20	1.08
	2002-12-05	171 ± 11	180 ± 14	1.05

Table 7.09: Food/Vegetation

Analysis	Sample Date	QA Agent	NB Power (pCi/kg ± 2 sigma)	NB Power/QA Agent (ratio)
Ba-133	2002-02-18	1130 ± 120	1230 ± 115	1.09
Ce-139	2002-02-18	49 ± 5	46 ± 10	0.93
Ce-141	2002-09-12	300 ± 20	369 ± 41	1.23
	2002-09-12	300 ± 20	349 ± 41	1.16
	2002-09-12	300 ± 20	282 ± 36	0.94
	2002-12-05	188 ± 12	246 ± 27	1.31 Fail
	2002-12-05	188 ± 12	256 ± 27	1.36 Fail
	2002-12-05	188 ± 12	254 ± 28	1.35 Fail

Table 7.09 (continued): Food/Vegetation

Analysis	Sample Date	QA Agent	NB Power (pCi/kg ± 2 sigma)	NB Power/QA Agent (ratio)
Co-58	2002-06-13	171 ± 11	215 ± 35	1.26
	2002-06-13	171 ± 11	182 ± 33	1.06
	2002-06-13	171 ± 11	219 ± 35	1.28
	2002-09-12	182 ± 12	219 ± 30	1.20
	2002-09-12	182 ± 12	196 ± 29	1.08
	2002-09-12	182 ± 12	172 ± 26	0.95
	2002-12-05	235 ± 15	277 ± 32	1.18
	2002-12-05	235 ± 15	291 ± 32	1.24 Fail
	2002-12-05	235 ± 15	279 ± 32	1.19
Co-60	2002-06-13	213 ± 14	217 ± 22	1.02
	2002-06-13	213 ± 14	229 ± 22	1.08
	2002-06-13	213 ± 14	231 ± 22	1.08
	2002-09-12	279 ± 18	342 ± 28	1.23 Fail
	2002-09-12	279 ± 18	287 ± 25	1.03
	2002-09-12	279 ± 18	227 ± 22	0.81 Fail
	2002-12-05	279 ± 18	329 ± 27	1.18 Fail
	2002-12-05	279 ± 18	330 ± 27	1.18 Fail
	2002-12-05	279 ± 18	334 ± 27	1.20 Fail
	2002-03-01	297 ± 27	378 ± 54	1.25
	2002-09-01	262 ± 16	259 ± 48	0.99
	2002-02-18	1120 ± 115	1070 ± 54	0.96
Cr-51	2002-09-12	426 ± 28	620 ± 168	1.46
	2002-12-05	587 ± 38	893± 134	1.52 Fail
	2002-12-05	587 ± 38	839 ± 136	1.43 Fail
	2002-12-05	587 ± 38	808 ± 136	1.38 Fail
Cs-134	2002-06-13	206 ± 14	219 ± 25	1.06
	2002-06-13	206 ± 14	220 ± 27	1.07
	2002-06-13	206 ± 14	210 ± 24	1.02
	2002-09-12	247 ± 16	307 ± 33	1.24 Fail
	2002-09-12	247 ± 16	256 ± 29	1.04
	2002-09-12	247 ± 16	210 ± 27	0.85
	2002-12-05	168 ± 11	199 ± 26	1.18
	2002-12-05	168 ± 11	194 ± 24	1.15
	2002-12-05	168 ± 11	192 ± 26	1.14

Table 7.09 (continued): Food/Vegetation

Analysis	Sample Date	QA Agent	NB Power (pCi/kg ± 2 sigma)	NB Power/QA Agent (ratio)
Cs-137	2002-06-13	156 ± 10	158 ± 20	1.01
	2002-06-13	156 ± 10	171 ± 22	1.10
	2002-06-13	156 ± 10	175 ± 22	1.12
	2002-09-12	238 ± 15	285 ± 30	1.20
	2002-09-12	238 ± 15	245 ± 27	1.03
	2002-09-12	238 ± 15	216 ± 25	0.91
	2002-12-05	373 ± 24	426 ± 39	1.14
	2002-12-05	373 ± 24	430 ± 39	1.15
	2002-12-05	373 ± 24	466 ±41	1.25 Fail
	2002-03-01	8478 ± 432	9747 ± 621	1.15
	2002-09-01	8127 ± 405	8829 ± 567	1.09
	2002-02-18	9050 ± 900	8070 ± 475	0.89
Fe-59	2002-09-12	166 ± 11	221 ± 51	1.33
	2002-09-12	166 ± 11	167 ± 56	1.01
	2002-09-12	166 ± 11	139 ± 44	0.84
	2002-12-05	122 ± 8	173 ± 41	1.42
	2002-12-05	122 ± 8	162 ± 40	1.33
	2002-12-05	122 ± 8	106 ± 39	0.87
K-40	2002-03-01	23328 ± 1269	26028 ± 2349	1.12
	2002-09-01	39960 ± 2106	43200 ± 3375	1.08
Mn-54	2002-06-13	163 ± 11	178 ± 24	1.09
	2002-06-13	163 ± 11	196 ± 25	1.20
	2002-06-13	163 ± 11	198 ± 25	1.21
	2002-09-12	286 ± 19	307 ± 33	1.07
	2002-09-12	286 ± 19	319 ± 34	1.12
	2002-09-12	286 ± 19	254 ± 30	0.89
	2002-12-05	241 ± 16	298 ± 32	1.24 Fail
	2002-12-05	241 ± 16	311 ± 33	1.29 Fail
	2002-12-05	241 ± 16	314 ± 33	1.30 Fail
	2002-02-18	147 ± 15	139 ± 18	0.95

Table 7.09 (continued): Food/Vegetation

Analysis	Sample Date	QA Agent	NB Power (pCi/kg ± 2 sigma)	NB Power/QA Agent (ratio)
Zn-65	2002-06-13	308 ± 20	353 ± 55	1.15
	2002-06-13	308 ± 20	377 ± 57	1.22
	2002-06-13	308 ± 20	351 ± 53	1.14
	2002-09-12	353 ± 23	418 ± 60	1.18
	2002-09-12	353 ± 23	386 ± 56	1.09
	2002-09-12	353 ± 23	351 ± 55	0.99
	2002-12-05	303 ± 20	358 ± 48	1.18
	2002-12-05	303 ± 20	398 ± 57	1.31 Fail
	2002-12-05	303 ± 20	385 ± 52	1.27

Table 7.10: Soil

Analysis	Sample Date	QA Agent	NB Power (pCi/kg ± 2 sigma)	NB Power/ QA Agent (ratio)
Ce-141	2002-09-12	249 ± 16	284 ± 37	1.14
	2002-09-12	249 ± 16	294 ± 39	1.18
	2002-12-05	196 ± 13	177 ± 24	0.90
	2002-12-05	196 ± 13	182 ± 24	0.93
Co-58	2002-09-12	151 ± 10	207 ± 30	1.37 Fail
	2002-09-12	151 ± 10	215 ± 30	1.42 Fail
	2002-12-05	244 ± 16	209 ± 26	0.86
	2002-12-05	244 ± 16	245 ± 29	1.00
Co-60	2002-06-13	168 ± 11	219 ± 24	1.30 Fail
	2002-06-13	168 ± 11	221 ± 24	1.32 Fail
	2002-09-12	232 ± 15	268 ± 25	1.16
	2002-09-12	232 ± 15	278 ± 26	1.20
	2002-12-05	290 ± 19	221 ± 21	0.76 Fail
	2002-12-05	290 ± 19	247 ± 22	0.85
Cr-51	2002-09-12	354 ± 23	515 ± 155	1.45
	2002-12-05	610 ± 40	536 ± 116	0.88
	2002-12-05	610 ± 40	622 ± 120	1.02
Cs-134	2002-06-13	163 ± 11	229 ± 31	1.40 Fail
	2002-06-13	163 ± 11	243 ± 31	1.49 Fail
	2002-09-12	205 ± 13	279 ± 34	1.36 Fail
	2002-09-12	205 ± 13	261 ± 32	1.27 Fail
	2002-12-05	174 ± 11	130 ± 24	0.75 Fail
	2002-12-05	174 ± 11	146 ± 22	0.84

Table 7.10 (continued): Soil

Analysis	Sample Date	QA Agent	NB Power (pCi/kg ± 2 sigma)	NB Power/ QA Agent (ratio)
Cs-137	2002-06-13	208 ± 14	313 ± 35	1.50 Fail
	2002-06-13	208 ± 14	336 ± 35	1.62 Fail
	2002-09-12	282 ± 18	403 ± 40	1.43 Fail
	2002-09-12	282 ± 18	390 ± 40	1.38 Fail
	2002-12-05	471 ± 31	445 ± 40	0.94
	2002-12-05	471 ± 31	426 ± 38	0.90
	2002-03-01	35910 ± 1809	31590 ± 1836	0.88
	2002-09-01	22383 ± 1134	20547 ± 1215	0.92
Fe-59	2002-09-12	138 ± 9	181 ± 46	1.31
	2002-09-12	138 ± 9	179 ± 50	1.30
	2002-12-05	127 ± 8	127 ± 35	1.00
	2002-12-05	127 ± 8	111 ± 34	0.87
K-40	2002-03-01	16794 ± 918	15309 ± 1296	0.91
	2002-09-01	17226 ± 918	15930 ± 1350	0.92
Mn-54	2002-06-13	129 ± 8	189 ± 28	1.47 Fail
	2002-06-13	129 ± 8	210 ± 31	1.63 Fail
	2002-09-12	238 ± 15	338 ± 36	1.42 Fail
	2002-09-12	238 ± 15	316 ± 35	1.33 Fail
	2002-12-05	250 ± 16	229 ± 27	0.92
	2002-12-05	250 ± 16	241 ± 28	0.96
Zn-65	2002-06-13	243 ± 16	362 ± 45	1.49 Fail
	2002-06-13	243 ± 16	362 ± 47	1.49 Fail
	2002-09-12	293 ± 19	411 ± 40	1.40 Fail
	2002-09-12	293 ± 19	395 ± 41	1.35 Fail
	2002-12-05	315 ± 21	330 ± 40	1.05
	2002-12-05	315 ± 21	326 ± 31	1.03

Table 7.11: Urine

Analysis	Sample Date	QA Agent	NB Power (pCi/L ± 2 sigma)	NB Power/QA Agent (ratio)
Ba-133	2002-09-01	57 ± 0	61 ± 2	1.07
C-14	2002-05-16	2900 ± 0	2720 ± 101	0.94
	2002-05-16	13300 ± 0	12300 ± 385	0.93
	2002-05-16	486000 ± 0	442000 ± 12350	0.91
Co-60	2002-09-01	149 ± 0	144 ± 8	0.97
Cs-137	2002-09-01	158 ± 0	147 ± 6	0.93
H-3	2002-04-18	91000 ± 0	82500 ± 2730	0.91
	2002-04-18	540000 ± 0	489000 ± 15700	0.91
	2002-04-18	9E6 ± 0	7E6 ± 2E5	0.82

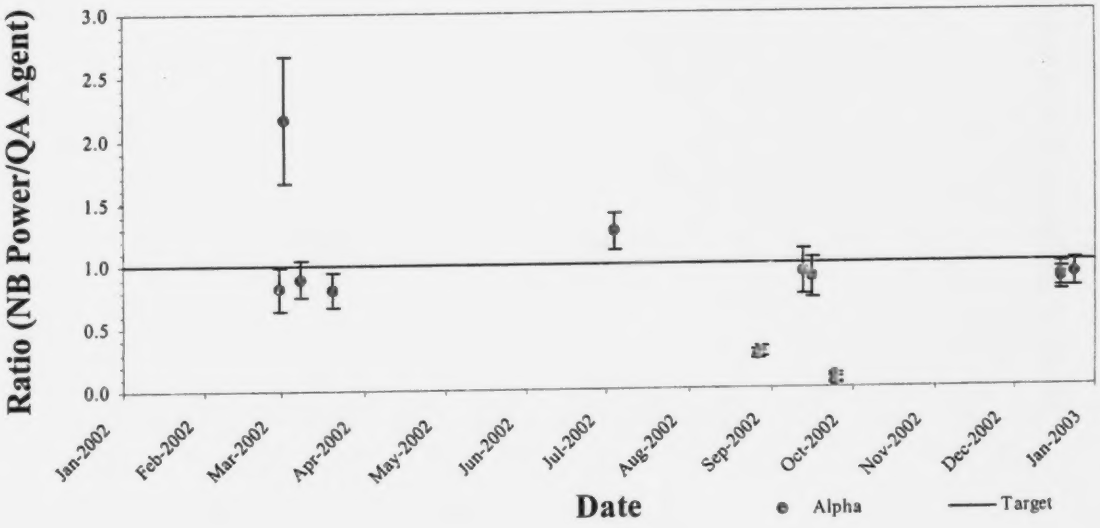

Figure 7.01: Alpha QA Performance (External Agencies)

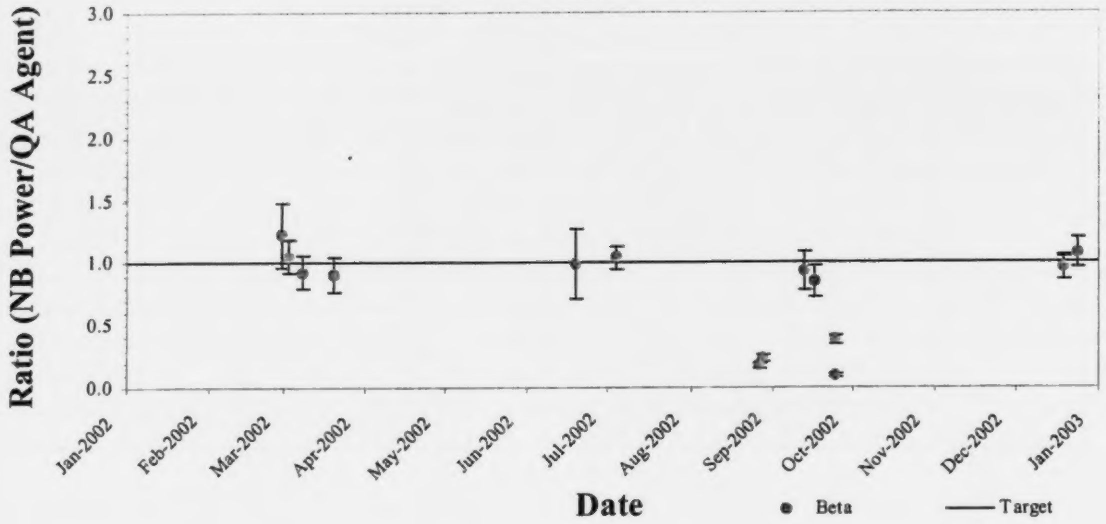

Figure 7.02: Beta QA Performance (External Agencies)

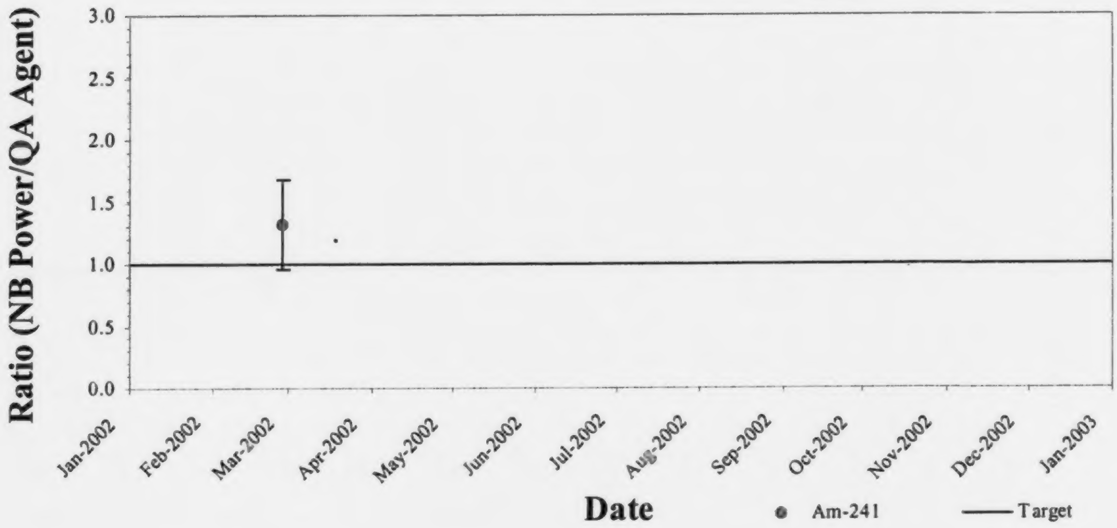

Figure 7.03: Am-241 QA Performance (External Agencies)

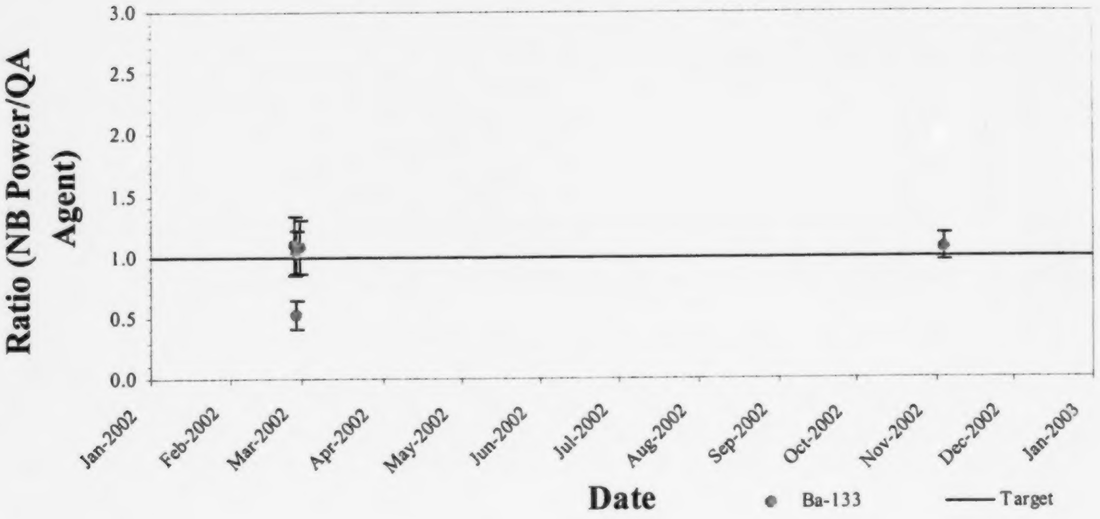

Figure 7.04: Ba-133 QA Performance (External Agencies)

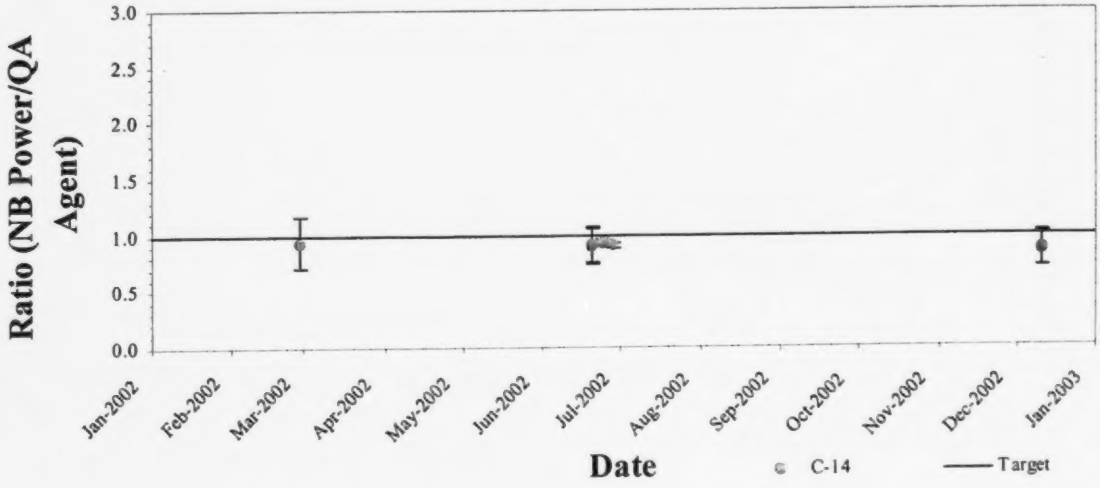

Figure 7.05: C-14 QA Performance (External Agencies)

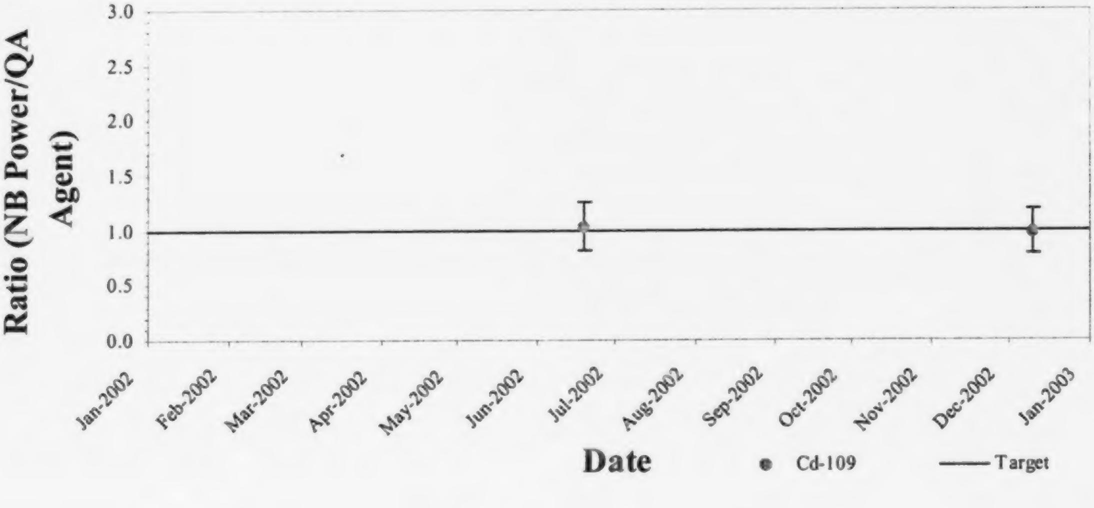

Figure 7.06: Cd-109 QA Performance (External Agencies)

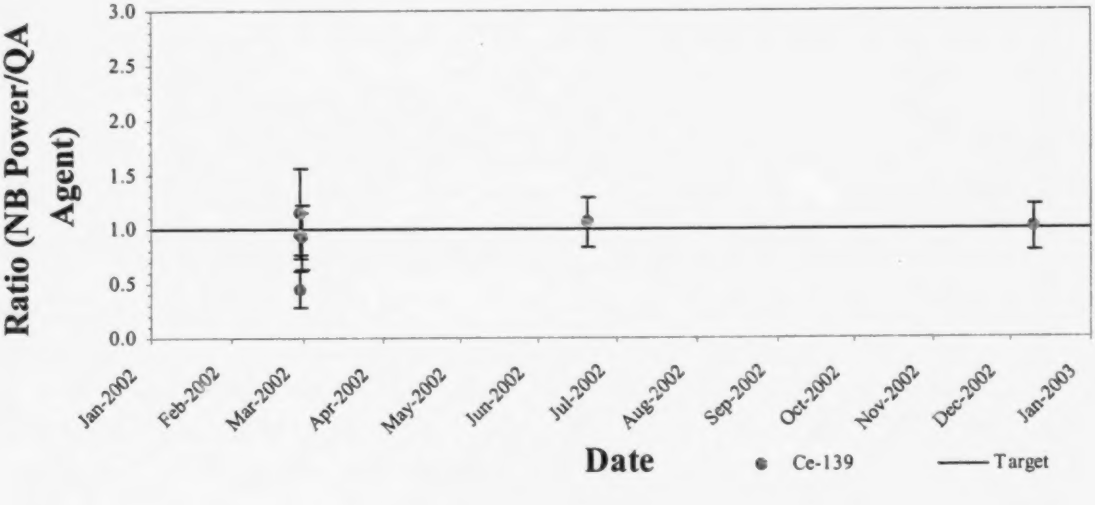

Figure 7.07: Ce-139 QA Performance (External Agencies)

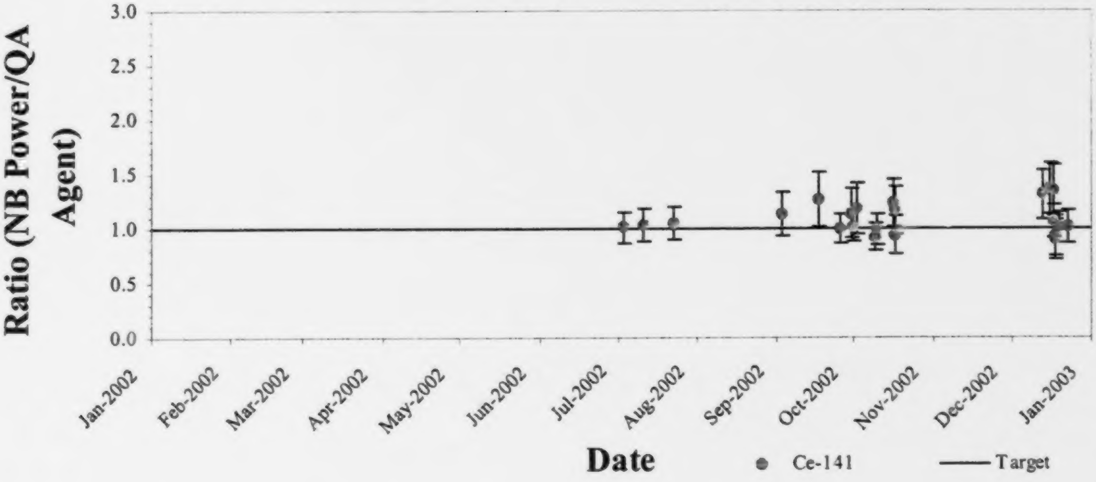

Figure 7.08: Ce-141 QA Performance (External Agencies)

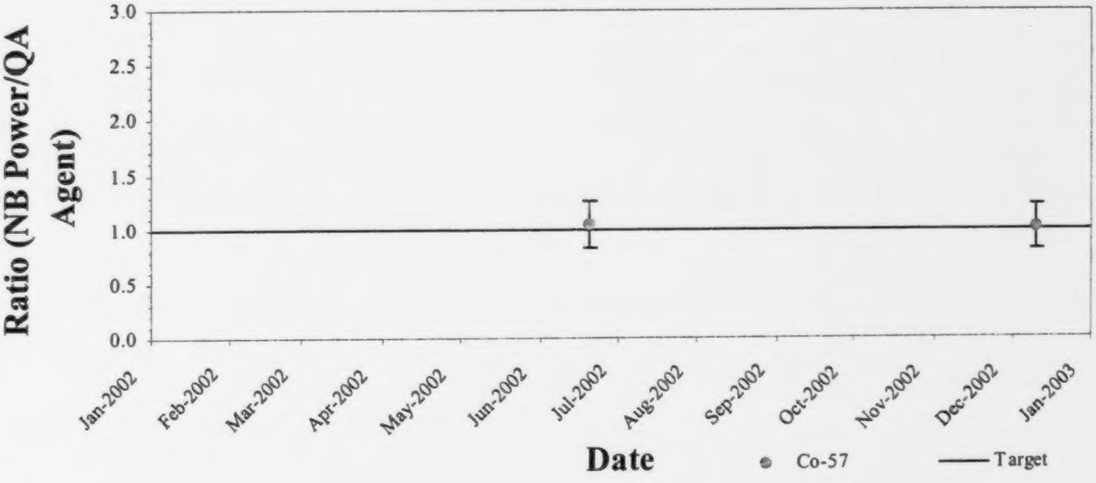

Figure 7.09: Co-57 QA Performance (External Agencies)

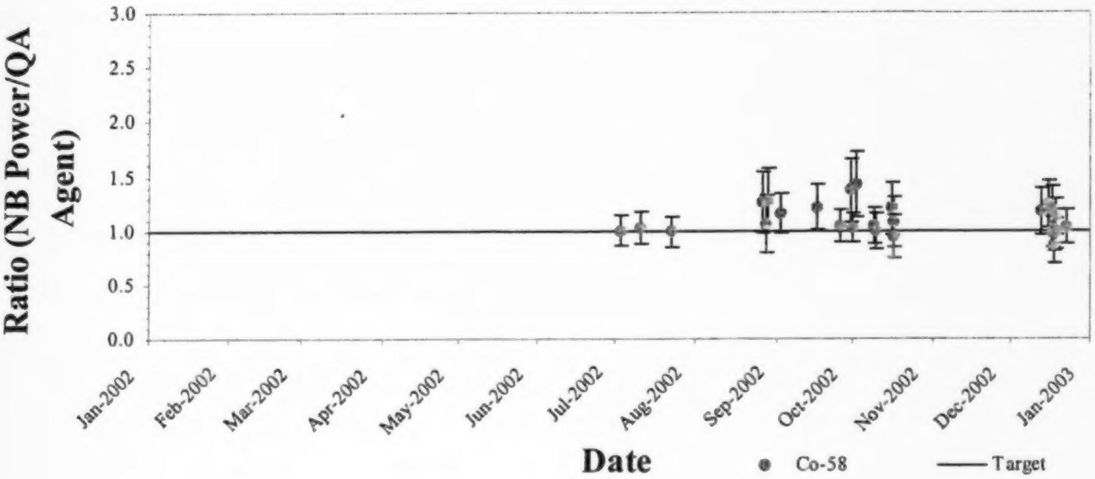

Figure 7.10: Co-58 QA Performance (External Agencies)

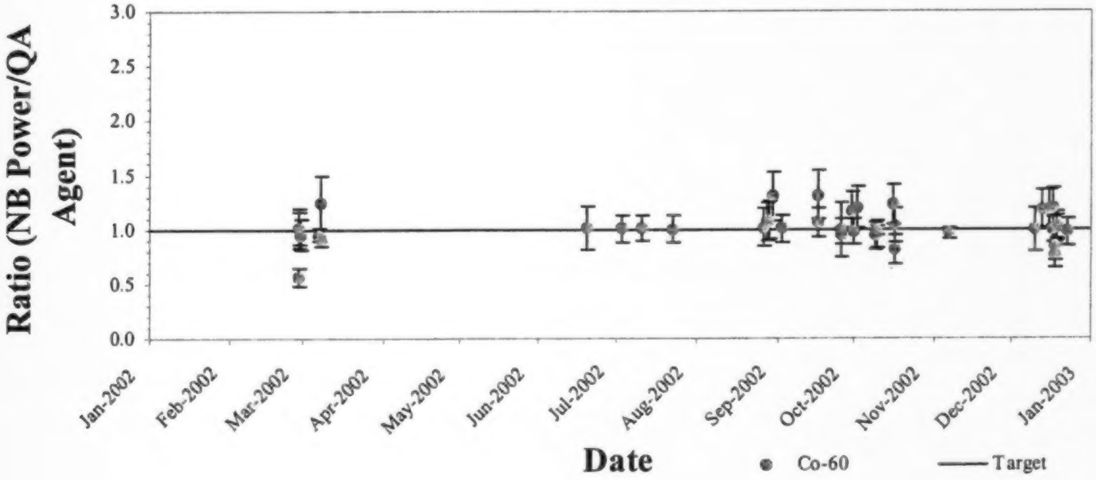

Figure 7.11: Co-60 QA Performance (External Agencies)

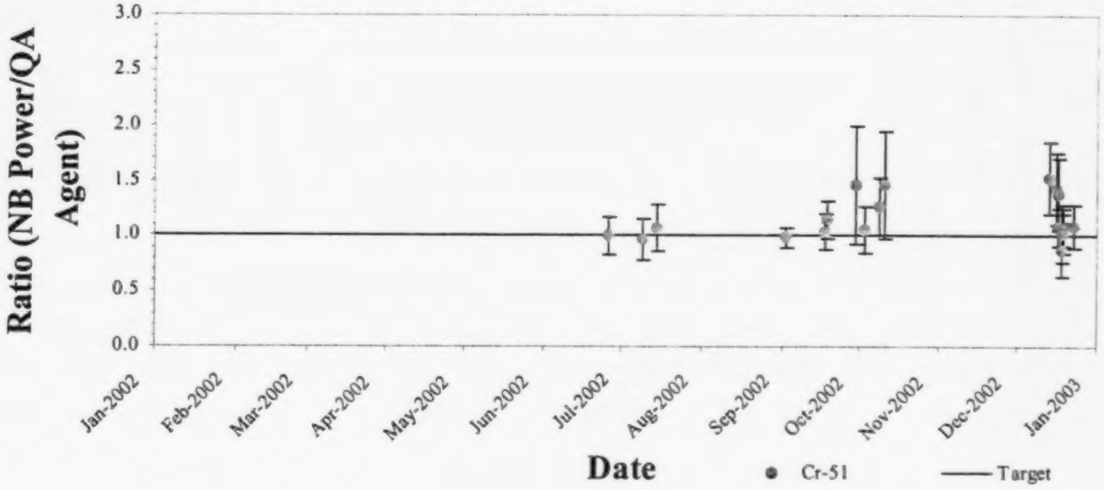

Figure 7.12: Cr-51 QA Performance (External Agencies)

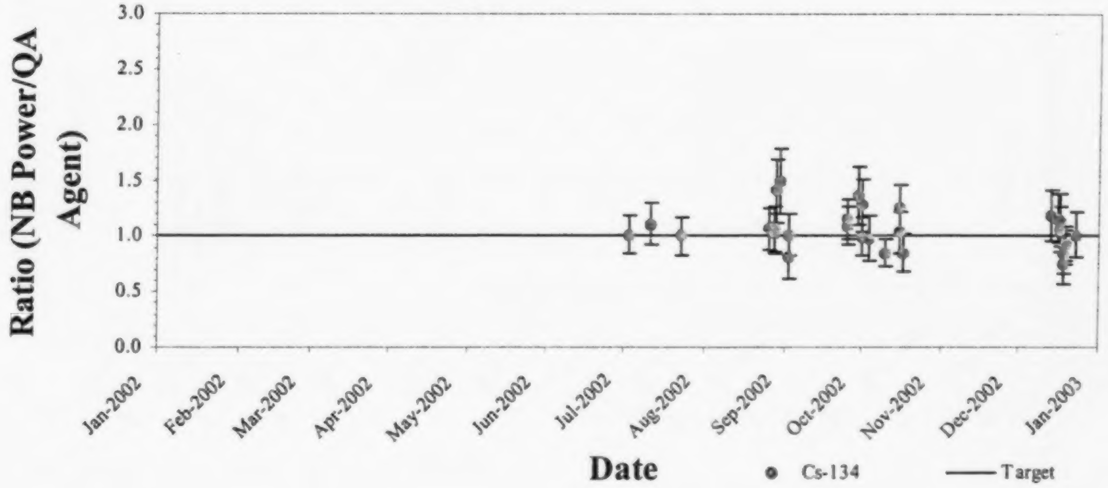

Figure 7.13: Cs-134 QA Performance (External Agencies)

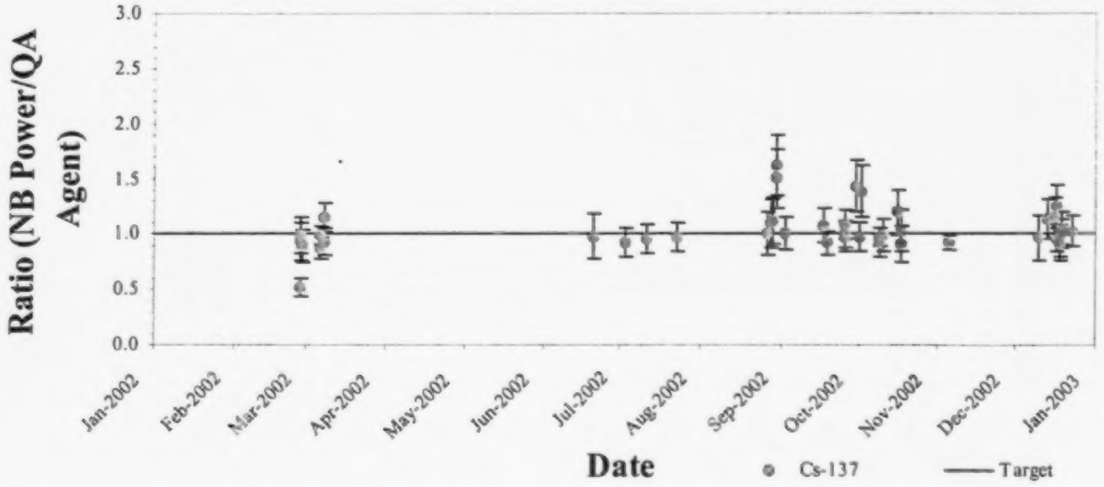

Figure 7.14: Cs-137 QA Performance (External Agencies)

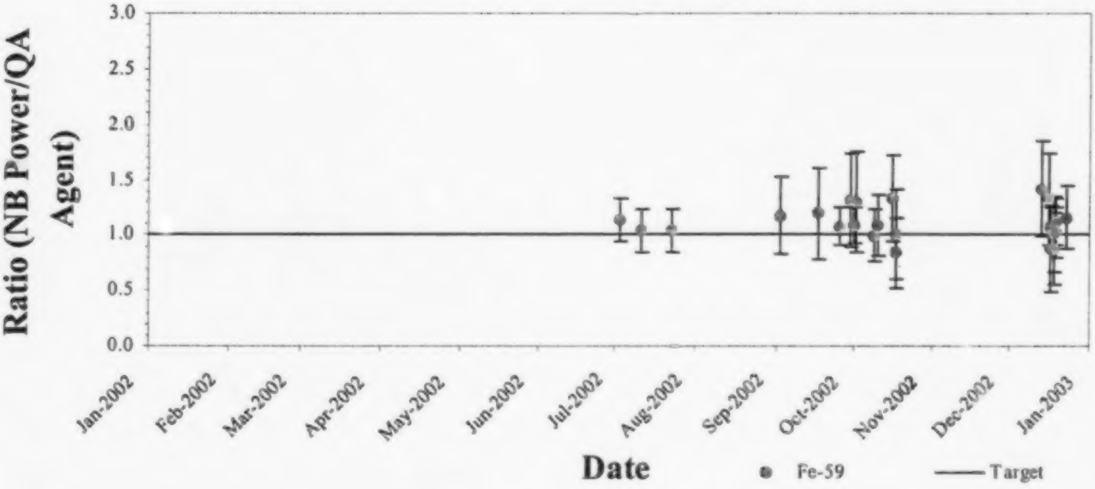

Figure 7.15: Fe-59 QA Performance (External Agencies)

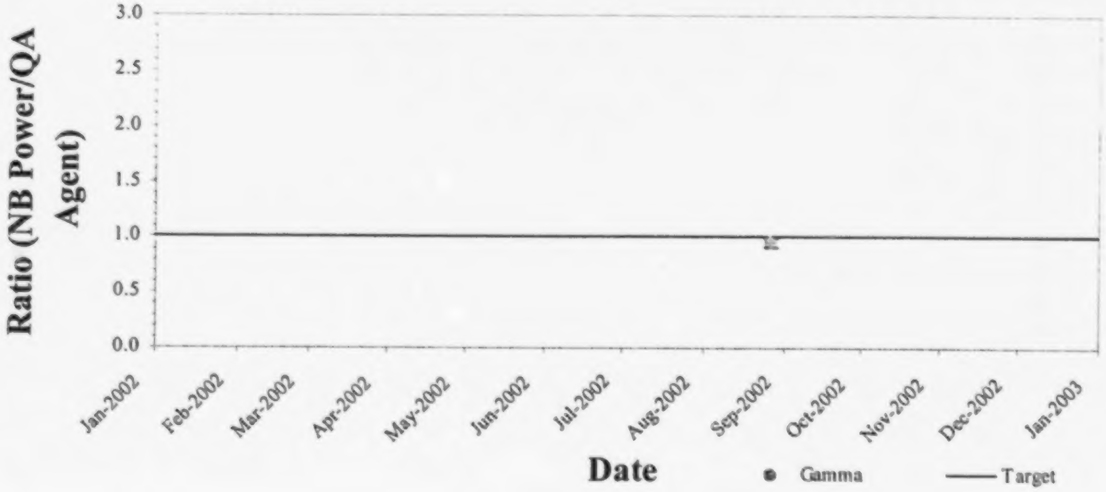

Figure 7.16: Gamma QA Performance (External Agencies)

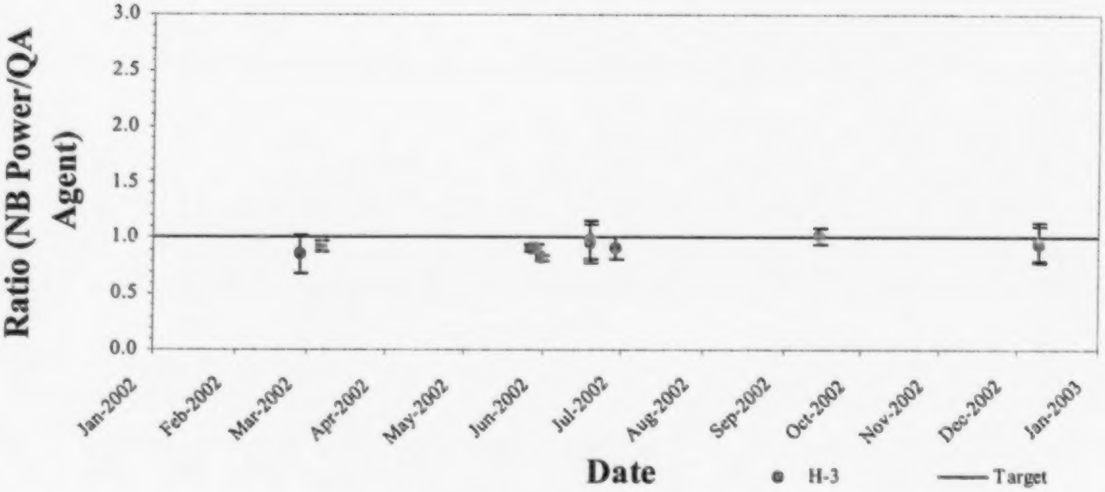

Figure 7.17: H-3 QA Performance (External Agencies)

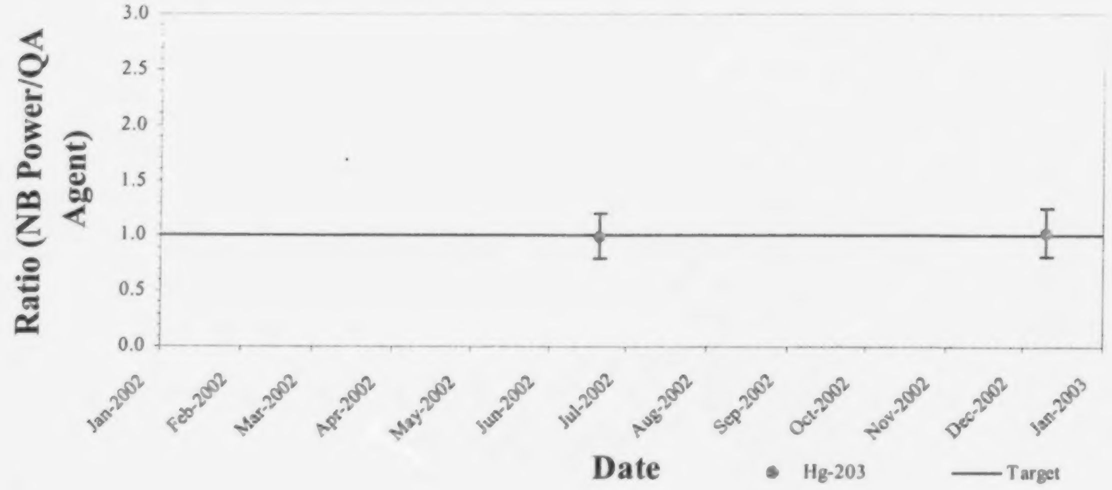

Figure 7.18: Hg-203 QA Performance (External Agencies)

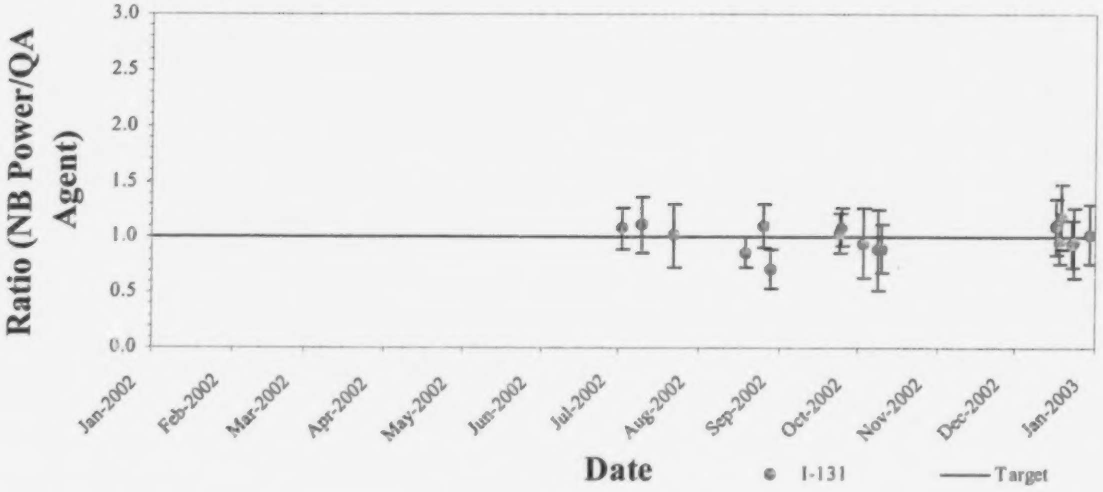

Figure 7.19: I-131 QA Performance (External Agencies)

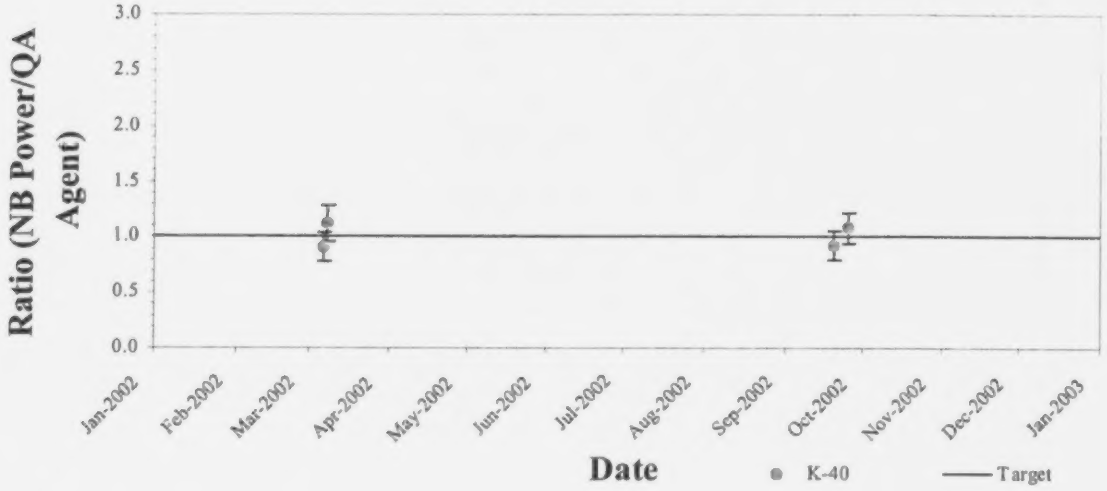

Figure 7.20: K-40 QA Performance (External Agencies)

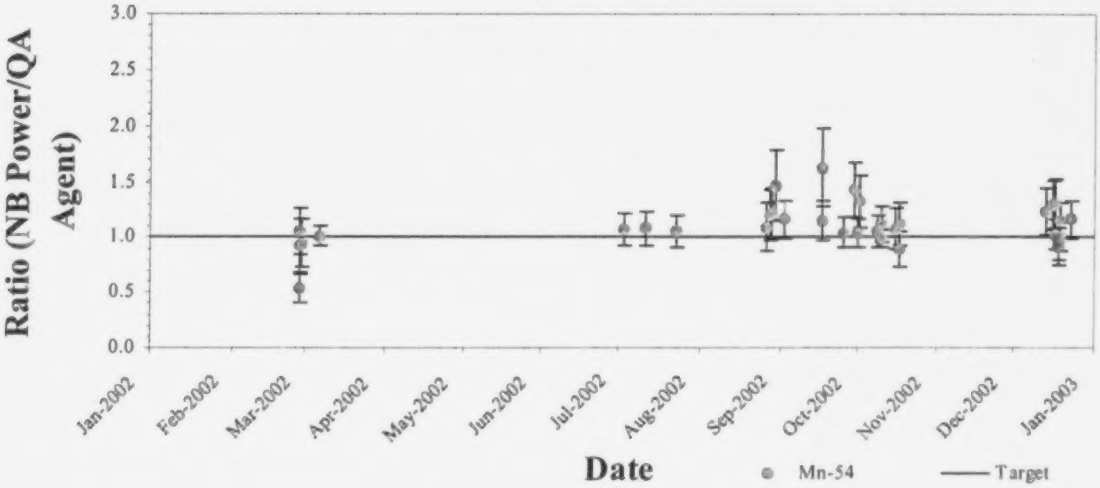

Figure 7.21: Mn-54 QA Performance (External Agencies)

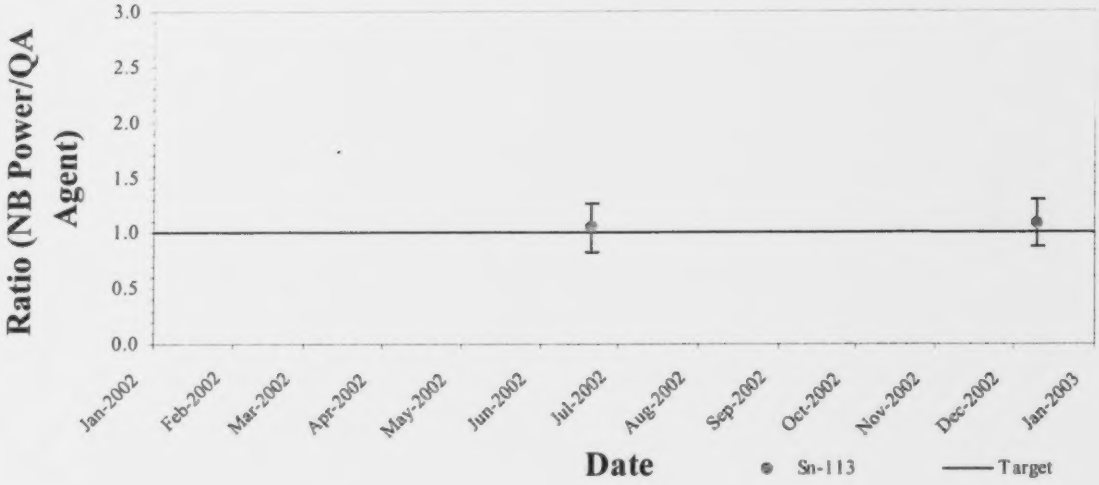

Figure 7.22: Sn-113 QA Performance (External Agencies)

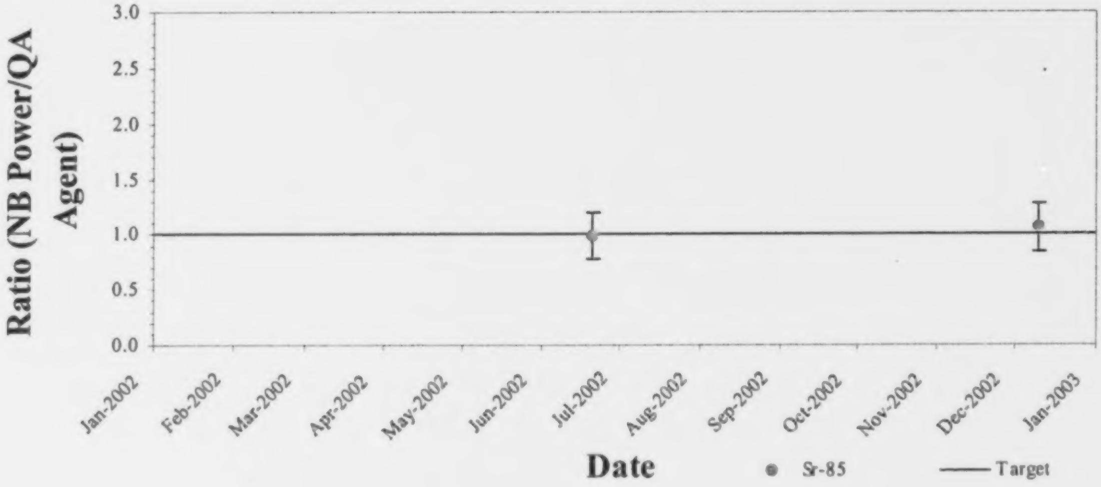

Figure 7.23: Sr-85 QA Performance (External Agencies)

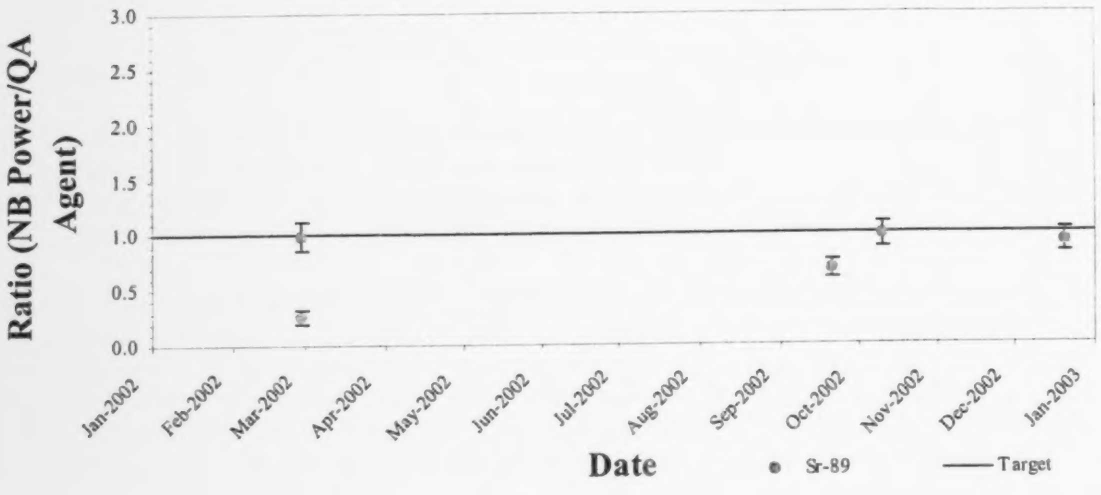

Figure 7.24: Sr-89 QA Performance (External Agencies)

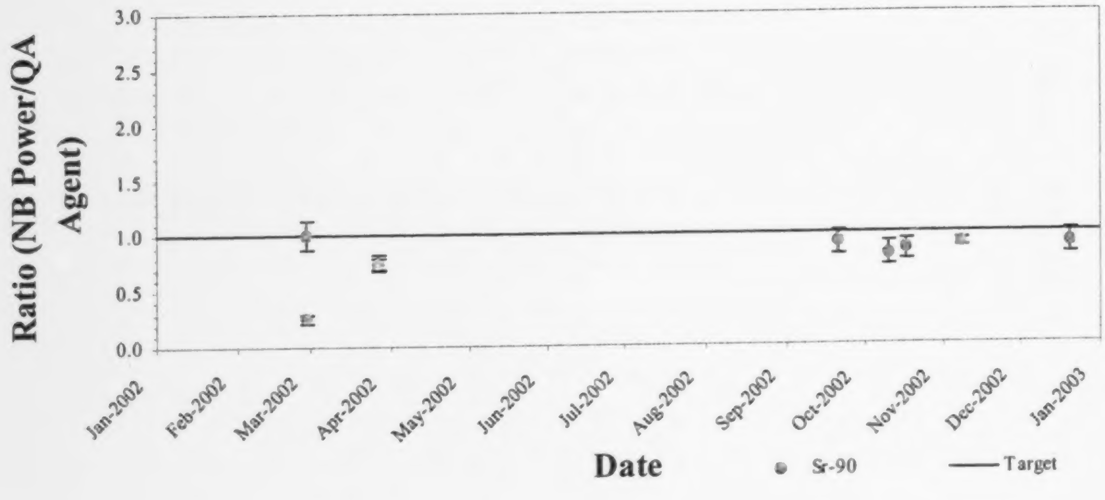

Figure 7.25: Sr-90 QA Performance (External Agencies)

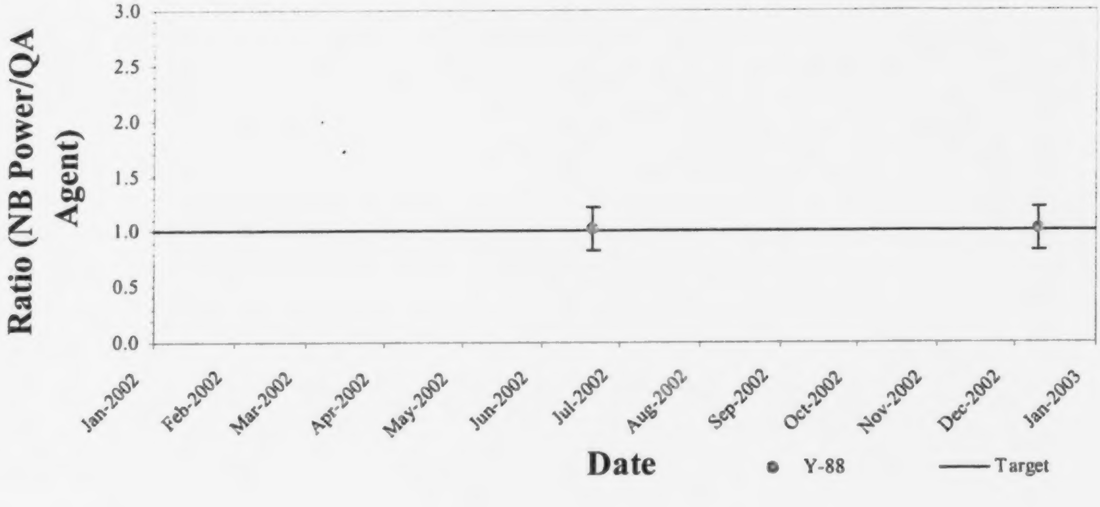

Figure 7.26: Y-88 QA Performance (External Agencies)

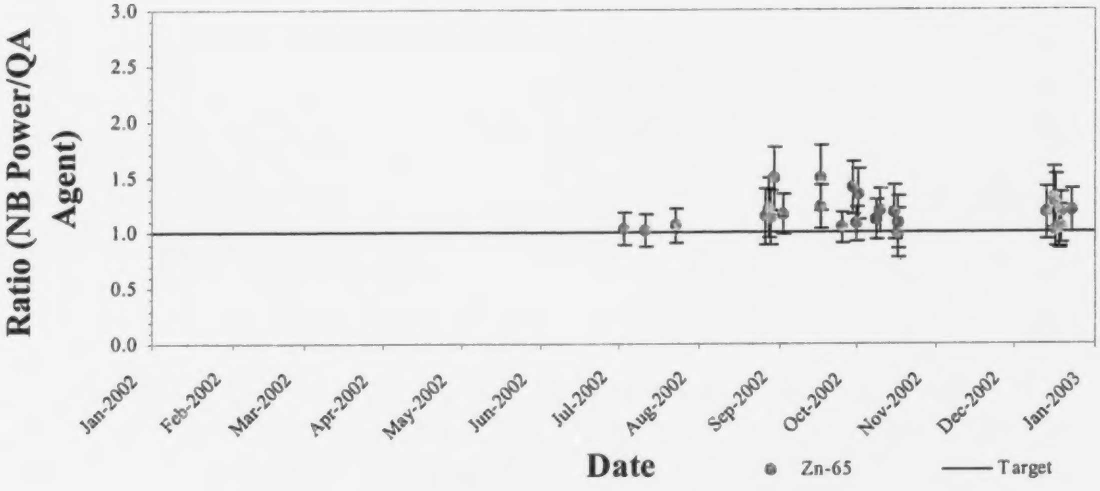

Figure 7.27: Zn-65 QA Performance (External Agencies)

7.03 Internal QA

There are four parts to Internal QA:

1) duplicate samples – two samples collected at the same time and analysed separately
2) replicate analyses – two analyses done on the same sample
3) spiked samples – one person spikes a sample and a different person performs the analysis
4) repeated analyses of calibration standards or stock solutions

Duplicate samples and replicate counts are employed as part of the overall quality assurance program. For those media where two samples can be obtained from the same location at the same time, similar analytical results are expected. This approach demonstrates that the samples are representative of the medium in that area. Where duplicate samples are not possible, e.g., air filters, a sample is counted twice to demonstrate reproducibility in the counting system. Results of performance with these samples gives an indication of how reproducible our measurements are.

Tracking of results is done in a spreadsheet and performance is charted. If the range of the ratio (of the two detected measurements) plus or minus the combined uncertainty (95% confidence interval) includes 1.00, then performance is acceptable. See Table 7.12 for the frequency.

There were 209 radionuclide comparisons performed on 86 samples analysed. Four of these had failures in one of the comparisons:

- Be-7 in Airborne Iodines - two failures due to low activity.
- Cs-137 in Soil – one failure due to an inconsistency between the two samples.
- Beta in LEM Composite – one failure due to a difference in the deposit mass between the two samples.

The results are presented graphically in Figures 7.28 to 7.41 (plotted against the analysis date).

Table 7.12: Internal (Duplicate Samples/Replicate Analyses) QA Frequency

Medium	***Duplicate/Replicate***	***Number of Radionuclide Comparisons***	***Analyses***
Airborne Carbon Dioxide	Replicate analysis (single location)	9	LSC C-14
Airborne Iodines	Replicate count (1 composite set)	32	Gamma
Airborne Particulates	Replicate count	12	Gamma
		24	Alpha/Beta
Garden Vegetables	Replicate count & duplicate sample	7	Gamma
Milk	Duplicate sample	12	Gamma
Parshall Flume	Replicate count	10	LSC H-3
LEM Composite	Replicate count Replicate analysis	50	Gamma
		23	Alpha/Beta
		12	Sr-89,90
Sea Food	Replicate count	4	Gamma
Sediment / Soil	Duplicate sample	10	Gamma
Environmental Gamma	Duplicate sample (single location)	4	TLD

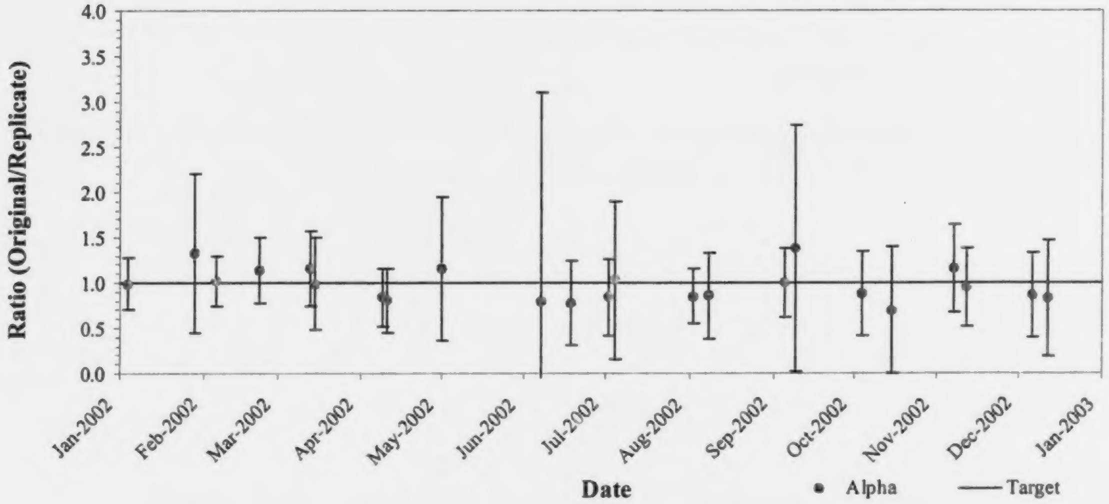

Figure 7.28: Alpha QA Performance (Internal - Duplicate Samples or Replicate Analyses

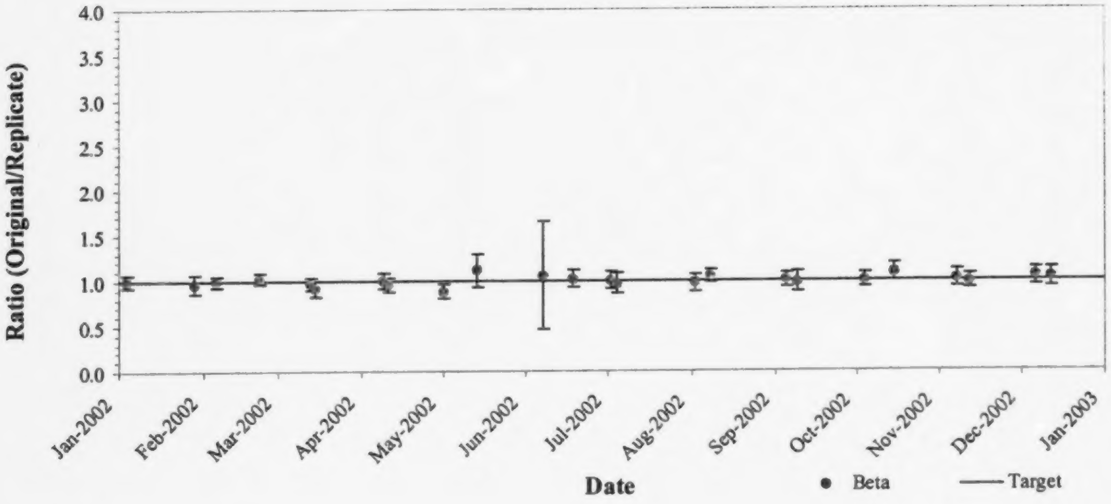

Figure 7.29: Beta QA Performance (Internal - Duplicate Samples or Replicate Analyses)

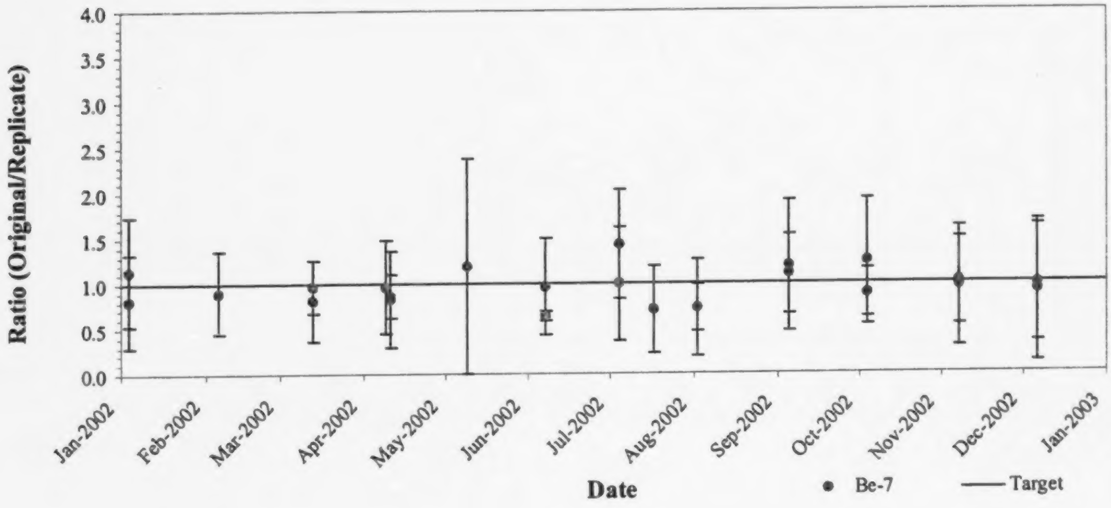

Figure 7.30: Be-7 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

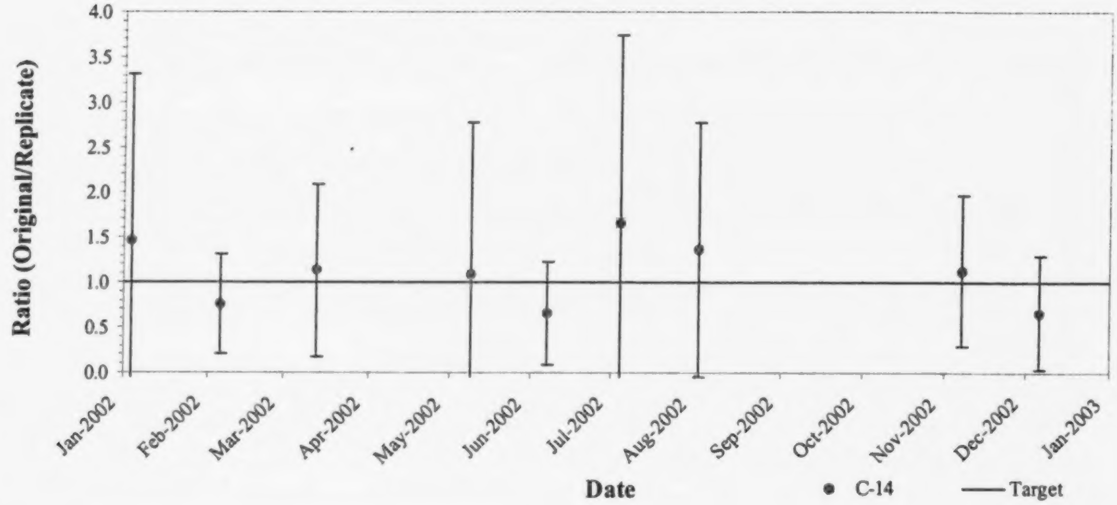

Figure 7.31: C-14 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

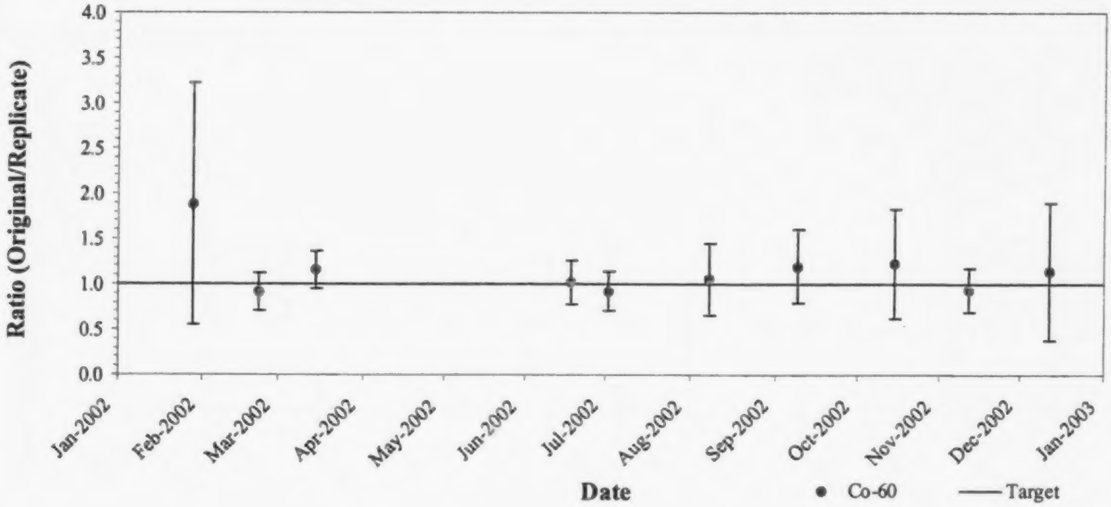

Figure 7.32: Co-60 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

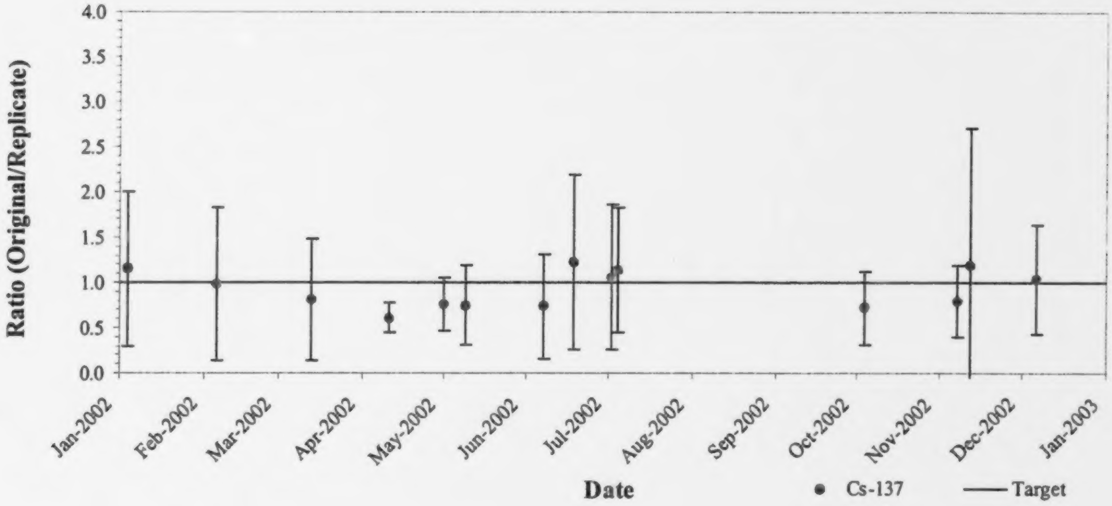

Figure 7.33: Cs-137 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

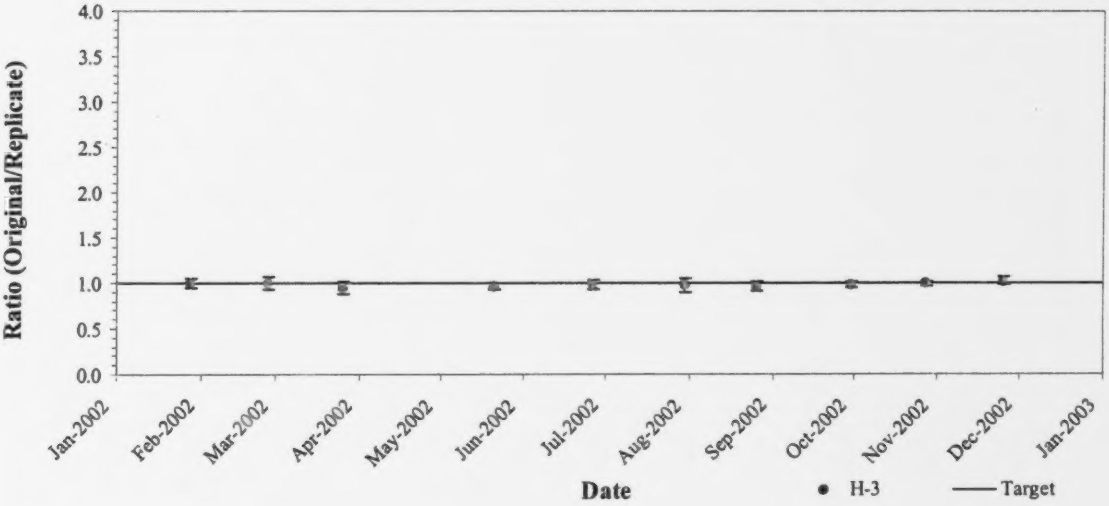

Figure 7.34: H-3 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

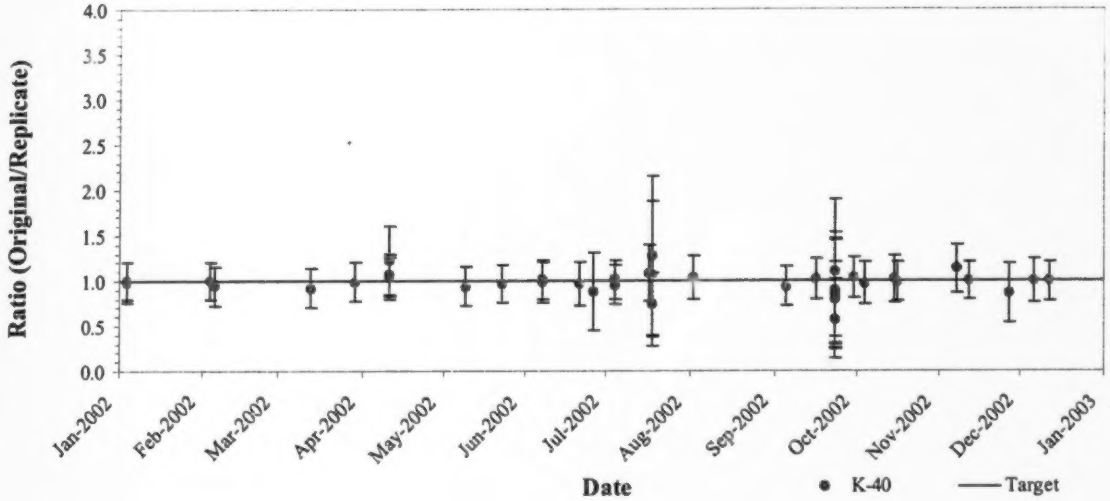

Figure 7.35: K-40 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

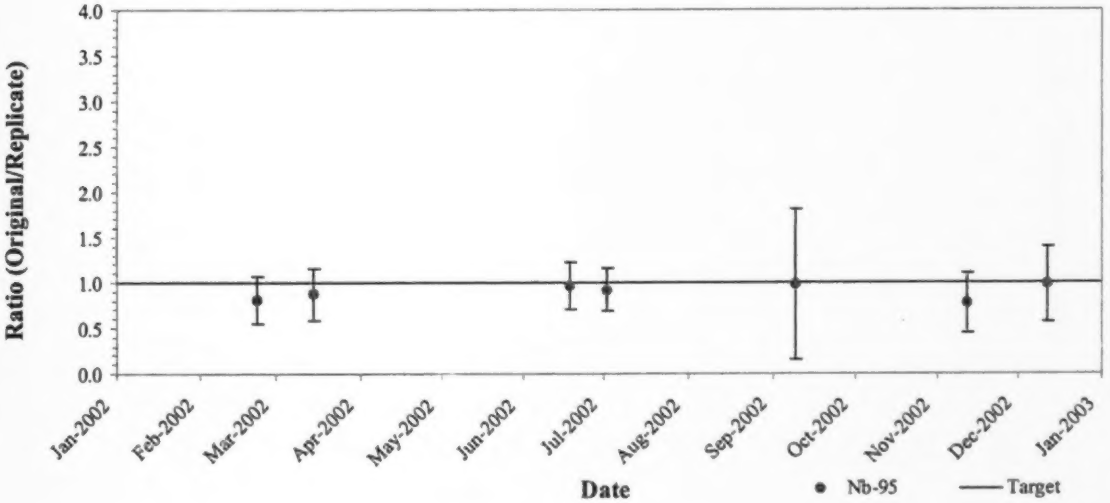

Figure 7.36: Nb-95 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

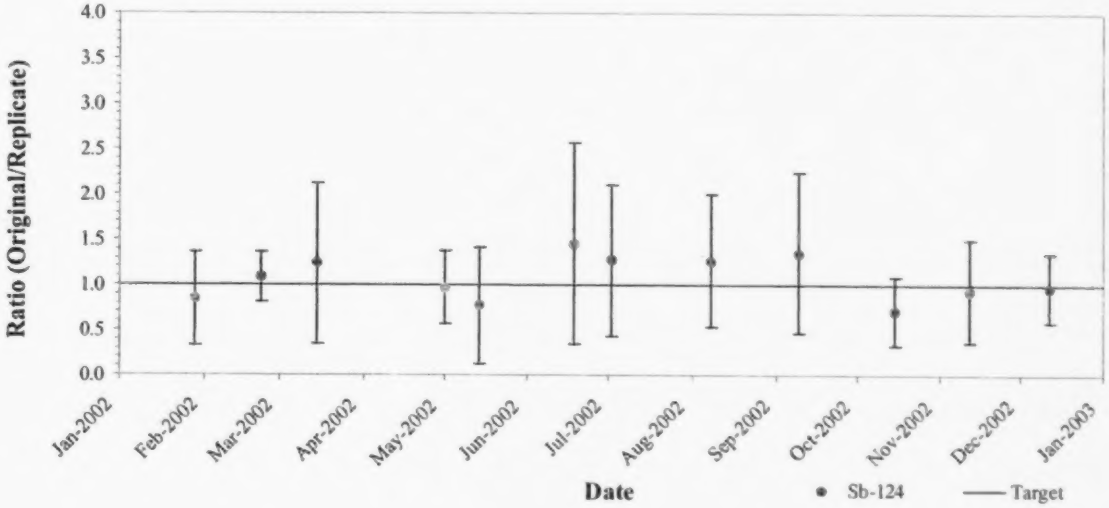

Figure 7.37: Sb-124 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

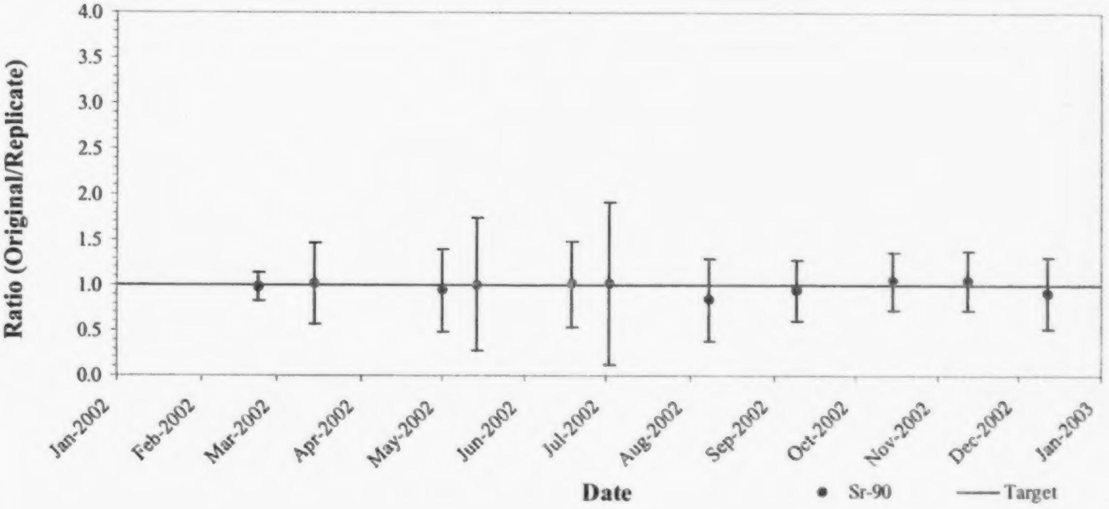

Figure 7.38: Sr-90 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

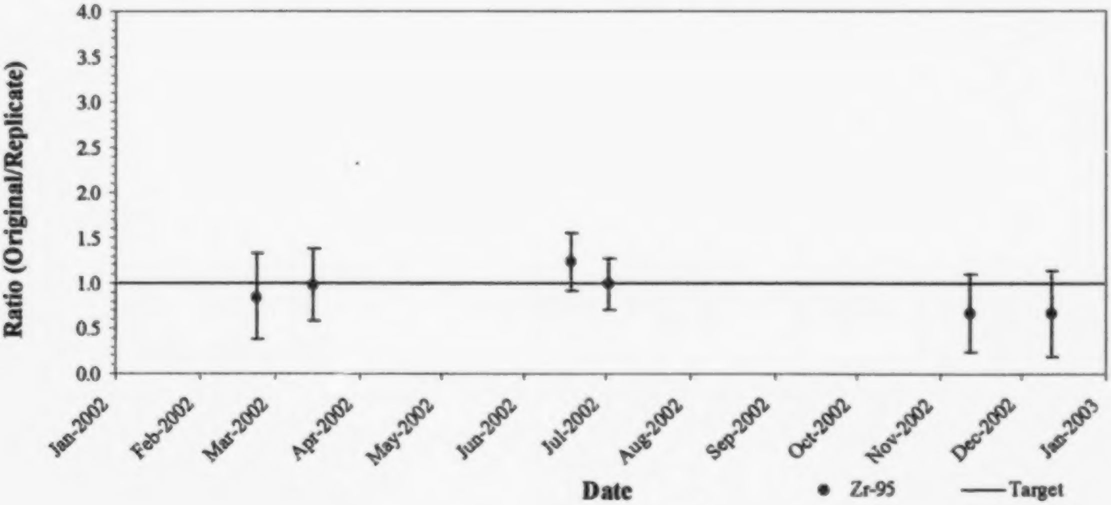

Figure 7.39: Zr-95 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

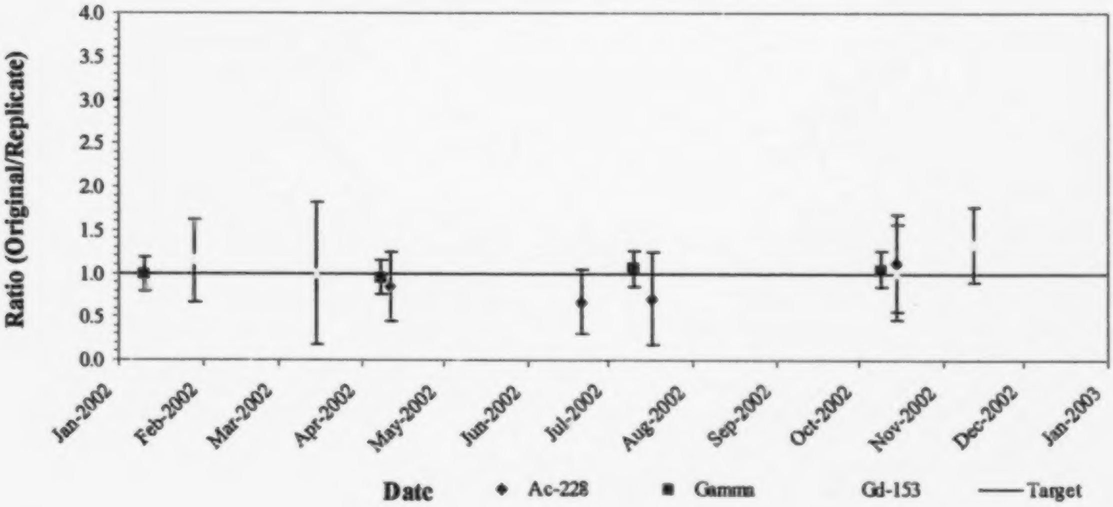

Figure 7.40: Ac-228, Gamma and Gd-153 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

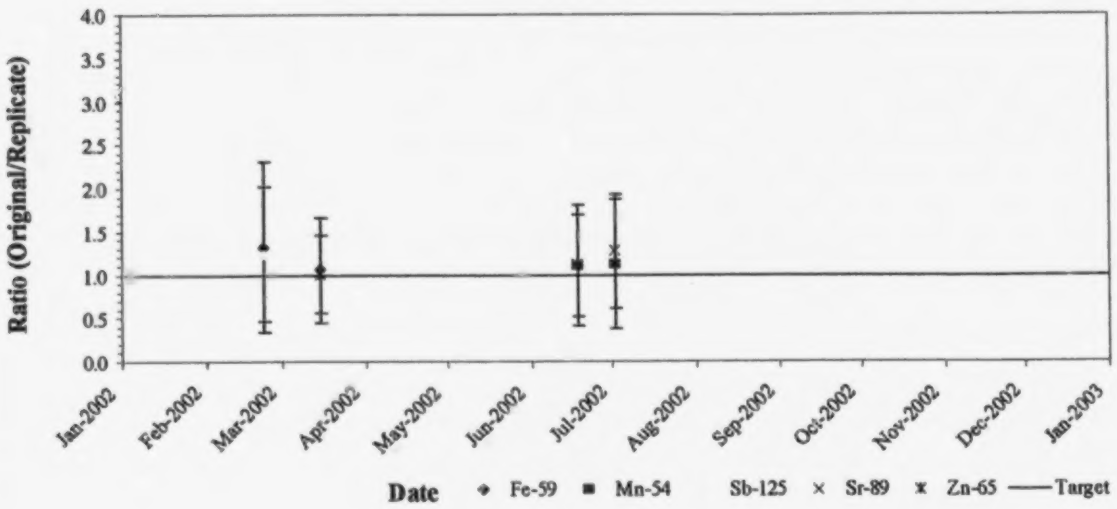

Figure 7.41: Fe-59, Mn-54, Sb-125, Sr-89 and Zn-65 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

The role of spiked samples in the overall quality assurance program was entirely replaced with an increase in external QA samples. The only exception is the irradiation of environmental TLDs. Similar to External QA, one member of the lab staff spikes (in this case, irradiates the TLDs) and a different person analyses the sample. Results of performance with these samples give an indication of the quality of measurements. Acceptable performance is defined as results within ± 10% of the expected value.

There were no failures in the three seperate tests (five TLDs for each test). The results are presented in Figure 7.42.

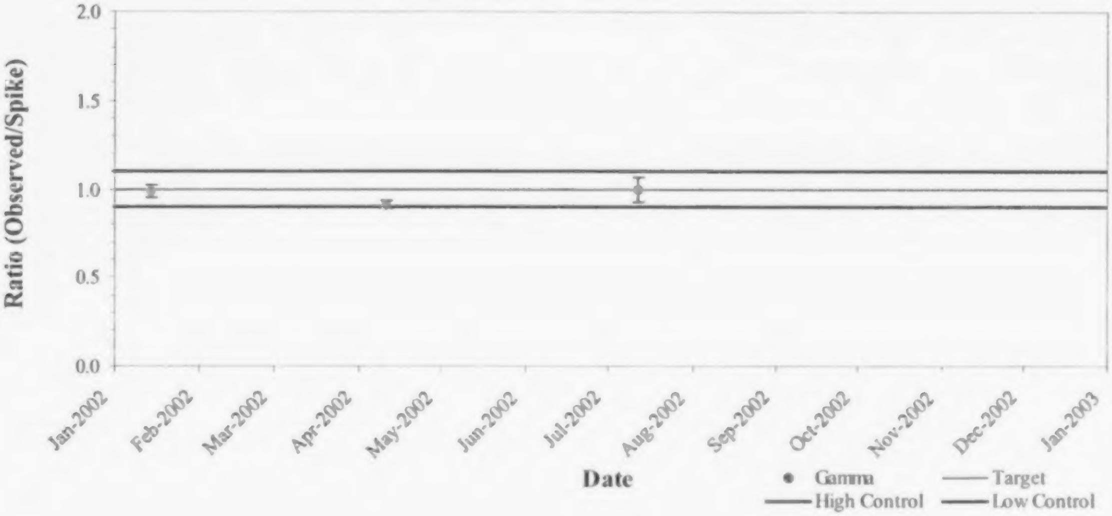

Figure 7.42: Gamma QA Performance (Internal – Spiked Samples)

As well, stock solutions of C-14 and H-3 and were repeatedly analysed throughout the year. The results are shown in Figures 7.43 and 7.44. These practices provide an extra degree of confidence in the Environmental Program. Acceptable performance is defined as results within ± 10% of the expected value. There were 19 individual radionuclide failures (all C-14) out of 97 tests. The poor performance of the C-14 is due to the age of the stock solution. A slightly negative bias is observed in the H-3 stock solution. This is due to the two to three percent difference between chemical quench and opacity quench. A positive bias is observed in the C-14 stock solution due to evaporation over many years.

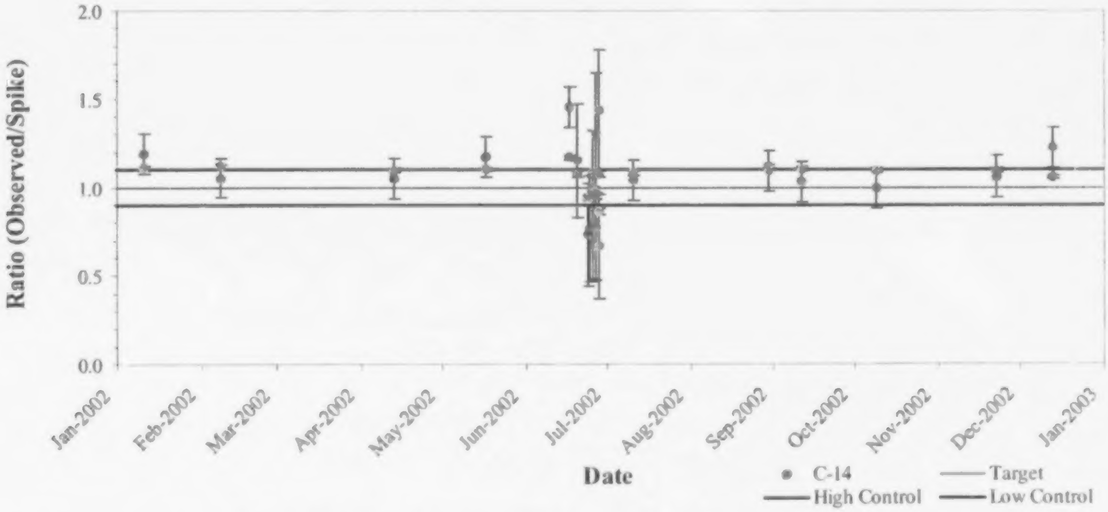

Figure 7.43: C-14 QA Performance (Internal – Repeated Analyses of Stock Solutions)

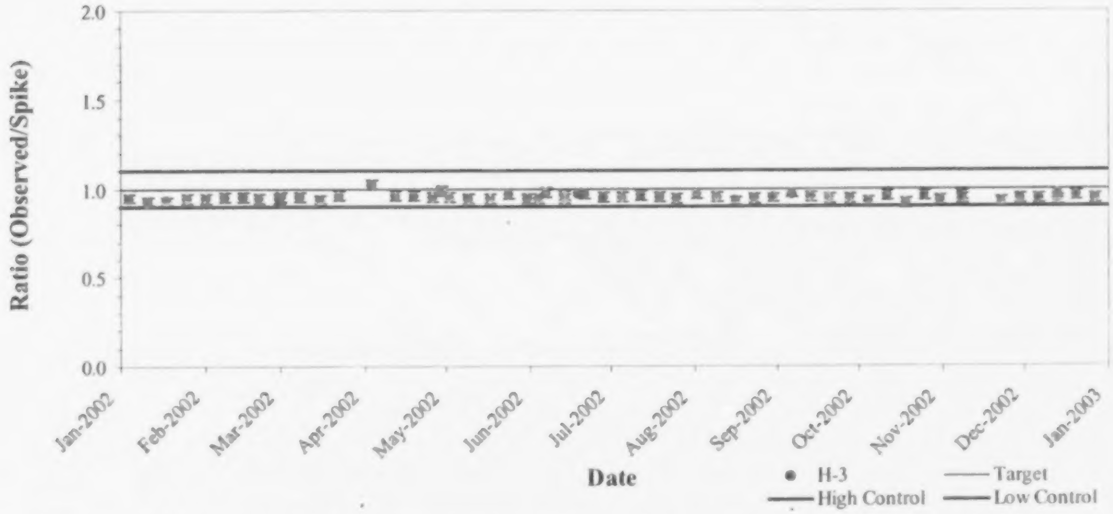

Figure 7.44: H-3 QA Performance (Internal – Repeated Analyses of Stock Solutions)

The laboratory also contracted out its services for several clients. A calibration standard was run with each set of samples to indicate to the customer the reliability of the results. There was one individual radionuclide failure out of 80 tests. This was a marginal failure that occurred when a very small standard (filter paper) was analysed. These results are presented in Figures 7.45 to 7.46. The figures show the analysis date.

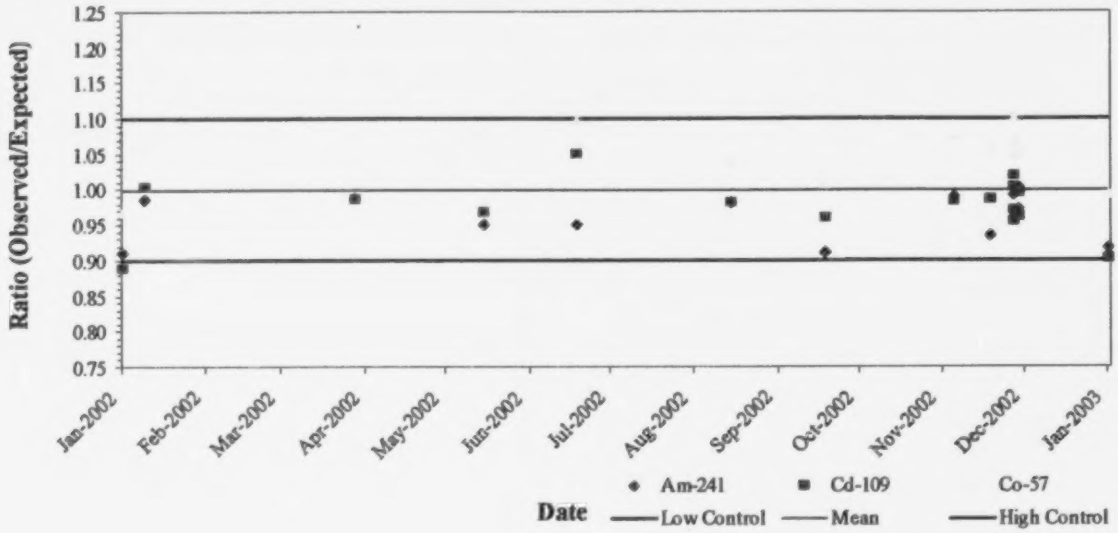

Figure 7.45: Am-241, Cd-109 and Co-57 QA Performance (Internal – Repeated Analyses of Calibration Standards)

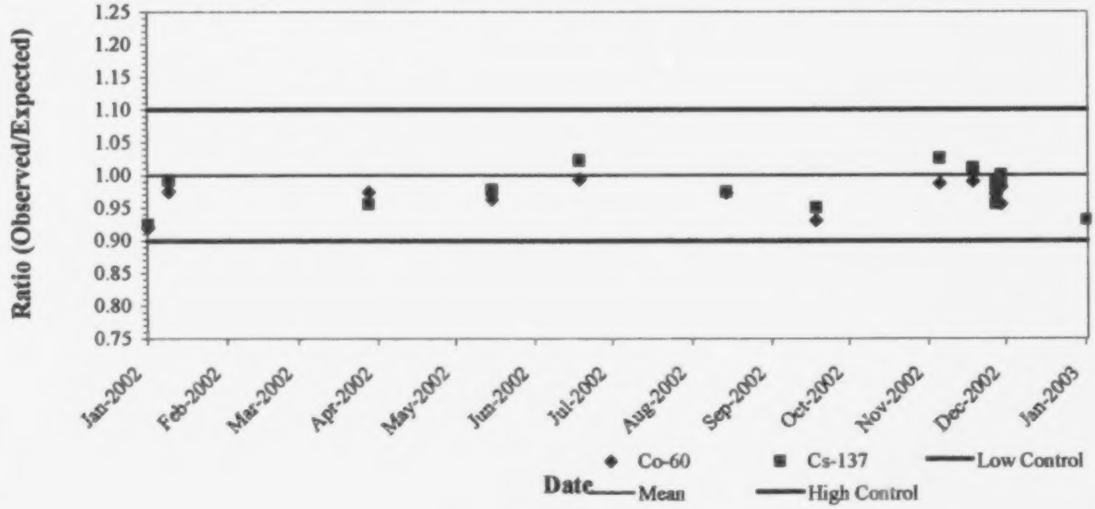

Figure 7.46: Co-60 and Cs-137 QA Performance (Internal – Repeated Analyses of Calibration Standards)

7.04 Program Audit

The OERMP is audited every three years. The Independent Assessment Group at PLGS is the principal auditor, although other groups from within NB Power, the CNSC, or other utilities may be used. The last audit was in 2000 and is due again in 2003.

In 2001, the Radiation and Environmental Protection Division (REPD) and Power Reactor Operation Division (PROD) of the CNSC, conducted its first evaluation of the OERMP. The official Findings from the audit were received after the end of 2001, and were rectified via the PICA process in 2002.

As part of its overall Management System, Point Lepreau has an Environmental Management System (EMS) in place that is registered to ISO 14001. Radiological releases to water and emissions to air are part of this. There were several environmental audits relating to the EMS during the year, although the OERMP was not specifically examined.

7.05 Annual Review

A major review of the Operational Environmental Radiation Monitoring Program (OERMP) takes place in February of each year. The requirement for this review is stated in the Reference Document (Operational Environmental Radiation Monitoring Program(10)) and described in the Procedure Document (Environmental Radiation Monitoring Program Procedures(14)). All members of the lab take part in this formal review, which is approved by the Manager, Personnel Safety and Environment by the end of March. Generally, all aspects of the program are looked at to make sure that the objectives, as stated in the Reference Document, are being met.

The following are the major items from the review:

1) A report, based on 2002 data, was issued early in 2003 which confirms previously expected groundwater movement on the peninsula and supports a reduced groundwater monitoring effort.
2) H-3 in Parshall Flume water was higher than in 2001, but lower than previous years.
3) H-3 in Bore Hole water continues a downward trend.
4) Resource constraints continued to be a challenge.
5) Work on new DELs was started.
6) A new, more reliable supplier of QA samples was engaged.

7.05.01 Routine Monitoring Results

The analyses results are examined for consistency and trends (using graphs and tables created for the Annual Report and using the performance indicators described in the Procedures). Any unusual results and problems are also examined.

This aspect of the review is discussed in sections 4 and 5 of this report.

7.05.02 Procedures

The adequacy and accuracy of field and laboratory procedures are evaluated. New or replacement methods are examined and obsolete ones are identified for deletion. Under the new program, procedures are checked every three years as are their execution by staff. Any deviations from these are to be documented in the Annual Report.

Procedures were issued early in 2001 with an expiry date of three years. This will be changed to four years (i.e., due for revision by 2005).

The only deviation from the written procedures was the increase in count time for the gamma QC from 1000 s to 1500 s.

7.05.03 Analytical QA Results

Failures and biases associated with the Analytical QA Program and the Daily QC Checks are addressed. Graphs and tables produced for the Annual Report as well as the QC Failure Log Book are used. Schedules, number of samples and problems are addressed. The degree of satisfaction with external agencies and options for different suppliers of these samples are explored.

This aspect of the review is discussed in Sections 7.01 to 7.03 of this report. The number of QA samples overburdened the resources of the laboratory and resulted in long decay periods before some QA samples were analysed. Fewer samples will be ordered in 2003.

The C-14 stock solution will be replaced.

7.05.04 Equipment

The status of laboratory and field equipment, software and facilities are considered.

Laboratory – All equipment is in good shape. Plans for a refresh of BIN components are being made by PLGS.

Software – Plans for an upgrade to the Genie 2000 gamma spectrometry system are progressing, as is the changeover from the current Alpha based computer system to an NT box.

Field

- Groundwater monitoring equipment was purchased and will be brought into use.
- A second beta/gamma contamination meter will be acquired from PLGS for field use (expedite access to controlled areas).
- A method for tracking power outage duration at the EMBs will be implemented.

- The condition of an EMB (G02) continues to deteriorate but will not need to be replaced in 2003.
- Another EMB will be considered for movement to outside of a fenced in area to make access easier.

7.05.05 Personnel

Training during the previous year is reviewed and plans for the coming year are made from the point of view of program requirements and employee development. Human resources available to accomplish program objectives are evaluated.

Training suffered in 2002 due to resource constraints. However, a training program for each of the three laboratory positions was developed and implemented.

7.05.06 Safety

Laboratory and field work safety is reviewed.

Restrictions on working alone in the field was better defined. In particular, the collection of seawater at Q01R and the changing of the C-14 bubblers were discussed with the goal of reducing hazards.

7.05.07 Emissions

The final gaseous and liquid effluent reports are studied. Their impact on routine monitoring results and their implications to the OERMP are assessed.

There were no unusual emissions that warranted any change to the program. Work on a major revision to the DELs commenced as a cooperative undertaking with all COG members.

7.05.08 Meteorological Data

The impact on routine monitoring results and the implications to the OERMP are assessed. The results of the Meteorological Monitoring QA analysis are discussed.

The temperature bias in the 42 metre tower data was still not resolved. Meteorological data are now collected from two different places, but changes are still required to take advantage of this.

7.05.09 Emergency Measures Organisation Demographic Data

When available, these data are studied for implications to the program.

The survey took place in 2001. The results were not available from New Brunswick Emergency Measures Organization (NBEMO) for analysis at year end. They will be incorporated in the major revision to the DELs, which commenced in 2002. A new survey was designed, which will further aid in the DEL revision.

7.05.10 Appropriateness of Media, Locations and Frequency

The choice of media, and location and frequency of sampling are examined in the broader context of the past year. Possible adjustments are examined to reflect changing conditions in the Lepreau area and future plans and expectations for PLGS from the public and CNSC.

Several reports (see Section 8) were issued early in 2003 that may require minor modifications to the program. They will be studied in more detail as the year progresses. The final version of the Priority Substance List II (Environment Canada) and four Guidance Documents (CNSC), dealing with the environment, have not been released. Action plans will be developed when these reports are received.

In the summer of 2000, a geotechnical firm evaluated the onsite groundwater movement and made recommendations for an improved monitoring program. Based on their advice, nine new bore holes in and around the SRWMF and eleven new monitoring wells near the plant were drilled, bringing the total to 35. In the fall of 2001, the CNSC inspected these new wells and met with NB Power's hydrogeologists. An enhanced monitoring program was established to give a better understanding of groundwater movement. Each well was sampled three times in 2002. At the same time that the samples were taken, physical data were recorded. At the end of 2002, these data were given to the hydrogeologists for evaluation. A report was issued by the geotechnical firm early in 2003 which confirmed previously expected groundwater movement on the peninsula.

Tritium concentrations averaged 360 Bq/L, ranging up to 1300 Bq/L. Tritium levels in the groundwater are decreasing, or are currently at a level below regulatory concern. The impact from current levels on humans and the environment is negligible. These results along with the report supports a reduced groundwater monitoring effort.

Changes:

- new monitoring well sampling equipment will be commissioned.
- the clam location at Dipper Harbour (N04) will be deleted due to Department of Fisheries restrictions (clams are too small)
- the frequency of bore hole and monitoring well sampling will be reduced from three times per year to two times per year (pending CNSC approval)
- a search for more private gardens will continue
- personnel will continue their efforts to obtain local aquaculture salmon and sea urchins

7.05.11 High LLDs

The summary report of dose to the Critical Group at the LLD is studied.

The major radionuclides that exceed the 5 μSv level (annual average) continue to be noble gases (detection is with a TLD which measures 20 μSv dose). However the noble gas spectrometer on the GEM allows for a much smaller LLD calculation. Other exceptions are:

- Ba-140 in soil (8.4 μSv); sediment (8.9 μSv)
- Ce-144 in pond/puddle/surface water (7.8 μSv); rain water (11.7 μSv); well water (13.5 μSv); garden vegetables (7.3 μSv)
- Co-60 in garden vegetables (5.5 μSv)
- Ru-106 in pond/puddle/surface water (9.3 μSv); rain water (15.6 μSv); well water (12.4 μSv); garden vegetables (19.0 μSv); berries (8.2 μSv); clams (6.4 μSv); fish (6.9 μSv)

Effluent analyses show these are not a major component of release and no changes to counting protocols are warranted.

7.05.12 Records

The completeness and consistency of data in the environmental records database are verified at the end of each monitoring year. A QA audit is also performed on the paper copies of analysis reports filed in the laboratory office. The changes to the database are documented.

There were only two changes made to the database:

- Correction of the location code for a milk sample. The wrong location code for a milk sample was used when the sample was logged into the database.
- Deletion of a Parshall Flume result. The sample was incorrectly labelled when collected.

7.05.13 Contamination

Results from routine contamination monitoring as well as equipment background checks are examined.

There were no contamination issues in 2002.

7.05.14 Problem Resolution

The PICA system at PLGS was implemented to identify, track and trend conditions, concerns, and problems and solutions.

The Health Physics Department has develop its own unique PICA codes to better track trends.

To date, the few entries made were for QA failures and air monitoring equipment failures (both described in preceeding sections).

7.05.15 Changes to Reference Document

Major changes since the last review are documented for the annual report.

The latest revision of the OERMP Reference Document was issued in January, 2000. A new revision is planned for one year after the four CNSC Guidance Documents are issued. Major changes to the current revision are:

Changes During 2000

- gross alpha/beta counting is never done on seawater or milk samples
- Sr-89,90 analysis is performed on air filters if more than 1% DEL (GEM) is released from PLGS
- Sr-89,90 analysis is performed on seawater if more than 1% DEL (LEM) is released from PLGS
- soil is not sieved or not always heated before counting
- procedures are checked at least every three years as are their execution by staff
- I-131 is not included in any QA samples
- Sr-89,90 and Cs-137 are not included in Duplicate/Replicate filter samples
- Sr-89 is not included in most QA samples
- the major review of the program takes place in February and is approved in March
- I00G (now I11G) is on the north fence (west side)
- I00I (now I11I) is on the north fence (east side)
- gross alpha/beta counting is done routinely on well water samples, but only on other water samples if they contain significant gamma activity
- three DELs were changed to match CNSC limits (Kr-85, I-131 and I-133)

Changes During 2001

- TLDs are no longer placed at B9, B10, I90-I95, I98 & I99
- well water is no longer collected at N03
- a new aquaculture salmon site has been added close to PLGS
- soil and gamma surveys were suspended at Hemlock Knoll
- 18 new bore holes and monitoring wells were added

Changes During 2002:

- an increase in the number of external QA samples replaced a decrease in the number of internal spikes
- a new groundwater sampling procedure was implemented
- All activities that support PLGS will be controlled by the PLGS Management System that is under development. The environmental monitoring program falls under the primary process *SU-2 Provide Environmental Services*. This process was mapped, and all sub-processes related to routine environmental monitoring come under it.
- clam location at Dipper Harbour (N04) deleted

Planned Changes for 2003:

- implementation of recommendations from
    - Ecological Risk Assessment
    - Environmental Assessment
    - Environment Canada's Priority Substance List 2
    - DEL document
    - four new CNSC guidance documents
- reduce the frequency of bore hole and monitoring well sampling from three times per year to two times per year (pending CNSC approval)
- make additions to reflect SU-2 and EMS
- C-14 analysis is performed on milk, water, berries, and garden vegetables if more than 1% DEL (GEM) is released from PLGS
- C-14 analysis is performed on seawater and seafood if more than 1% DEL (LEM) is released from PLGS
- H-3 analysis is performed on berries, and garden vegetables if more than 1% DEL (GEM) is released from PLGS
- H-3 analysis is performed on seafood if more than 1% DEL (LEM) is released from PLGS
- reduce the number of QA samples (a new schedule)

7.05.16 Program Audit

The results of any audits are reviewed.

This aspect of the review is discussed in Sections 7.04 of this report. There were several environmental audits relating to the EMS.

7.05.17 Program Improvement

Areas for improvement are identified:

- *from relevant operating experience (internal & external) (EN-418)*
- *during the annual review (EN-414)*
- *during audits*
- *by laboratory staff*
- *by other HP staff*
- *by HP manager*
- *by the self assessment process*

Deficiencies in any of the listed areas are dealt with promptly. The results of the Annual Review are used to improve the program, and are included in the Annual Report.

The preceeding sections describe many ways that the program will be improved in 2003.

8 Reports and Studies

Several reports were near completion at the end of the year, including a study of groundwater movement, an ecological effects review, an environmental assessment of the proposed SRWMF modifications (supporting PLGS refurbishment) and the process map for environmental services. Each of these has the potential for identifying changes to be made to the OERMP.

Work that began in 2002 and will continue into 2003 include the next revision of the DELs and the setting up of a NaI monitoring network by Health Canada.

The CNSC released a draft of S-99 in 2002, and may release four Regulatory Guidance Documents on the environment in 2003. Changes will have to be made to the OERMP to comply with these.

PLGS also issued the training document for the three positions that exist in the lab.

COG released four Technical Notes that contained some PLGS environmental data.

Appendices

Appendix A: Statistics, Detection Limits, and Dose at Detection Limits

A1 Statistics

The following statistical conventions are applied in the analysis of each sample:

- Detection limits are defined following the method described by Lochamy(15). The lower limit of detection (LLD) at the 99% confidence level is defined as 6.58 S_b, where S_b is the standard deviation of the appropriate radiation background measurement. This LLD corresponds to that amount of activity in a sample that will yield a net count greater than 3.29 S_b, or the so-called critical level (CL), with 99% probability. Thus, the LLD specifies the theoretical capability of the system to detect a given amount of radioactivity, whereas CL is used to determine whether an actual activity measurement should be considered detected. Any net measurement greater than 3.29 S_b is considered detected at the 99% confidence level. This also implies a 1% probability of stating that activity is present when it is not (false positive). If activity is present at the LLD level (6.58 S_b), there is a 1% probability of stating that activity is not present when it is (false negative).

- The CL of 3.29 S_b and LLD of 6.58 S_b apply in those analytical systems where the background levels are either not well defined, or where there is a relationship between the background levels and the detected signal above background, as in Ge gamma spectroscopy. Where the background readings are well defined and are independent of sample readings, as in the TLD data, the CL is 2.33 S_b and the LLD is 4.66 S_b.

- In most of the tables of data (Section 4.0), it is this Critical Level that appears in column 2.

- Unless otherwise indicated, the precision of the measurements reported here is given as ± 1.96 S_a (95% confidence level), where S_a is the standard deviation of the activity measurement.

- The value and standard deviation are reported with two significant figures using modified scientific notation, for example 0.032 is expressed as 3.2E-02.

The lower limits of detection (LLD) of all radionuclides in the various sample media are shown in Tables A.01 to A.11. The Annual Dose is to a member of the Critical Group. The LLDs are based on typical data. Decay of radionuclides is accounted for in the LLD calculations except for H-3 and C-14 (long half-lives). The major assumptions are that the sample is taken at one kilometre from the point of emissions and that the level is maintained for the year. Milk is assumed to be from a cow pastured at 1.5 km, fish and lobster are caught at the Condenser Cooling Water (CCW) outlet and sediment, dulse, seawater and clams are collected at Dipper Harbour.

The CSA recommends, where technically feasible, that all measurements achieve LLDs less than that which would result in a dose of 5 μSv to the Critical Group. Most radionuclides pass this criterion. The major exceptions are noble gases. Detection of this group is through TLD measurements (20 μSv dose to the Critical Group at the LLD). However, the noble gas spectrometer on the gaseous effluent monitor allows for a much smaller LLD calculation. Other exceptions are Ba-140 in soil and sediment (10 to 12 μSv); Ru-106 in water and clams (7 to 17 μSv); Ce-144 in water (11 μSv); and I-131 in food (8 μSv). Effluent analyses show these are not major components of release. Part of the QA process identifies those LLDs or activities that do not meet this target.

A1.01 Air

A1.01.01 Airborne Particulates

Typical LLDs are given for a 2400 m^3 sample, counted for 5000 s. The LLDs are decay corrected to the midpoint between the start and end of sampling, except for the gross alpha/beta results which represent the long-lived activity present a few days after sample collection. Gross alpha/beta is for trending only.

A1.01.02 Airborne Radioiodines

A typical LLD for I-131 is approximately 9E-05 Bq/m^3 (for a 2400 m^3 sample, counted for 50 000 s), which is decay corrected to the midpoint between the start and end of sampling.

A1.01.03 Airborne Tritium

The LLD is approximately 1E-01 Bq/m^3 of air for a typical sample of 10 to 70 m^3 (counted for 100 min). Due to the long half-life and relatively short period of time between sampling and analysis, decay correction is not applied.

A1.01.04 Airborne Carbon-14

A typical LLD is approximately 4E-02 Bq/m^3 of air for a 30 m^3 sample (counted for 100 min). Due to the long half-life and relatively short period of time between sampling and analysis, decay correction is not applied.

A1.01.05 TLD

The LLD is about 20 μSv. For typical quarterly measurements in the region of 150-200 μSv, measurements can be made to ± 10% at the 95% confidence level.

Table A.01 Annual Dose at the LLD for Air

Nuclide	*LLD (Bq/m^3)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/m^3)*
H-3	9.6E-02	4.8E-02	9.9E+00
C-14	4.0E-02	1.9E+00	1.0E-01
Cr-51	5.8E-04	3.2E-03	9.2E-01
Mn-54	7.8E-05	9.2E-02	4.3E-03
Fe-59	1.7E-04	6.1E-02	1.4E-02
Co-58	8.0E-05	3.5E-02	1.2E-02
Co-60	8.2E-05	1.7E+00	2.4E-04
Zn-65	1.9E-04	3.3E-01	2.9E-03
Kr-85	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Kr-85m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Kr-87	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Kr-88	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Zr-95	1.3E-04	1.1E-01	6.2E-03
Nb-95	9.4E-05	9.9E-02	4.7E-03
Ru-103	7.4E-05	8.1E-03	4.5E-02
Ru-106	6.0E-04	1.0E+00	2.9E-03
Ag-110m	6.2E-05	2.2E-01	1.4E-03
I-131	8.4E-05	1.6E-01	2.5E-03
Xe-131m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-133	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-133m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-135	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-135m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-138	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Cs-134	6.4E-05	4.3E-01	7.4E-04
Cs-137	6.6E-05	1.6E+00	2.0E-04
Ba-140	4.8E-04	8.9E-02	2.7E-02
La-140	2.0E-04	2.5E-03	4.1E-01
Ce-141	7.6E-05	4.8E-03	7.9E-02
Ce-144	2.2E-04	2.7E-01	4.0E-03
Noble Gases	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Gross Alpha	6.6E-06		
Gross Beta	1.7E-05		

A1.02 Milk

Typical LLDs for the nuclides of interest in milk (a 3.6 L sample counted for 50 000 s for gamma; 6 mL sample counted for 100 min for tritium) are listed in Table A.02 for the time of sample collection.

Table A.02 Annual Dose at the LLD for Milk

Nuclide	*LLD (Bq/L)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/L)*
H-3	2.4E+01	3.1E-01	3.9E+02
Cr-51	6.4E-01	1.0E-02	3.1E+02
Mn-54	9.2E-02	1.9E-02	2.5E+01
Fe-59	2.2E-01	2.2E-01	5.1E+00
Co-58	9.0E-02	7.5E-02	6.0E+00
Co-60	1.1E-01	9.0E-01	6.1E-01
Zn-65	2.4E-01	5.3E-01	2.3E+00
Zr-95	1.6E-01	4.3E-02	1.8E+01
Nb-95	9.2E-02	1.2E-01	3.8E+00
Ru-103	8.4E-02	1.9E-02	2.2E+01
Ru-106	7.8E-01	2.7E+00	1.4E+00
Ag-110m	8.2E-02	5.5E-02	7.4E+00
I-131	9.4E-02	1.8E+00	2.6E-01
Cs-134	7.8E-02	3.1E-01	1.3E+00
Cs-137	9.8E-02	3.1E-01	1.6E+00
Ba-140	3.4E-01	2.1E-01	8.1E+00
La-140	1.1E-01	8.9E-02	6.1E+00
Ce-141	1.2E-01	3.0E-02	2.1E+01
Ce-144	5.0E-01	9.5E-01	2.6E+00

A1.03 Water

The LLDs in Table A.03 apply to the midpoint between the start and end of sampling for a 3.6 L sample counted for 5000 s for gamma and a 6 mL sampled counted for 100 min for tritium. Alpha/beta results (a 200 mL sample counted for 100 min) represent the long-lived activity present several days after sample collection.

The LLDs are based on typical data for rainwater (the only water sample that has significant decay before analysis). Since decay of radionuclides is accounted for in the LLD calculations, Well Water and other water sample types will have lower LLDs than these. The major assumptions are that the sample is taken at one kilometre from the point of emissions, that the level is maintained for the year and the sample type is the major source of drinking water. Obviously this is not the case but it gives a simple "worst case" that is easy to monitor and calculate.

Table A.03 Annual Dose at the LLD for Water

Nuclide	*LLD (Bq/L)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/L)*
H-3	2.4E+01	3.4E-01	3.6E+02
Cr-51	5.4E+01	7.4E-02	3.7E+03
Mn-54	5.0E-01	1.7E-01	1.4E+01
Fe-59	1.3E+00	9.1E-01	7.1E+00
Co-58	5.6E-01	3.7E-01	7.5E+00
Co-60	4.6E-01	4.5E+00	5.1E-01
Zn-65	1.1E+00	2.3E+00	2.4E+00
Zr-95	9.8E-01	4.0E-01	1.2E+01
Nb-95	6.8E-01	4.0E-01	8.5E+00
Ru-103	6.4E-01	1.8E-01	1.8E+01
Ru-106	4.6E+00	1.7E+01	1.4E+00
Ag-110m	4.6E-01	6.2E-01	3.7E+00
I-131	2.4E+00	3.9E+00	3.1E+00
Cs-134	4.4E-01	4.8E+00	4.6E-01
Cs-137	5.2E-01	3.9E+00	6.6E-01
Ba-140	5.4E+00	2.7E+00	1.0E+01
La-140	2.2E+00	9.1E-01	1.2E+01
Ce-141	8.4E-01	3.4E-01	1.2E+01
Ce-144	2.4E+00	1.1E+01	1.1E+00
Gross Alpha	1.2E-01		
Gross Beta	8.4E-02		

A1.04 Food

The LLDs in Table A.04 apply to the time of sample collection. Samples are counted for 5000 s (size varies). The LLDs are based on typical data for garden vegetables. Garden vegetables have significant radioactive decay before analysis (the local residents harvest them and store them in their freezers for varying lengths of time). Since decay of radionuclides is accounted for in the LLD calculations, berries and other food sample types (which experience less radioactive decay) will have lower LLDs than these.

Table A.04 Annual Dose at the LLD for Food

Nuclide	*LLD (Bq/kg)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/kg)*
Cr-51	3.0E+01	5.9E-02	2.5E+03
Mn-54	3.4E+00	1.3E-01	1.3E+02
Fe-59	7.8E+00	8.4E-01	4.6E+01
Co-58	3.6E+00	3.0E-01	6.0E+01
Co-60	3.8E+00	3.9E+00	4.9E+00
Zn-65	9.0E+00	2.2E+00	2.1E+01
Zr-95	6.2E+00	3.3E-01	9.4E+01
Nb-95	4.0E+00	3.6E-01	5.6E+01
Ru-103	3.8E+00	1.7E-01	1.1E+02
Ru-106	3.0E+01	1.3E+01	1.1E+01
Ag-110m	3.0E+00	4.7E-01	3.2E+01
I-131	1.0E+01	6.9E+00	7.6E+00
Cs-134	3.0E+00	3.6E+00	4.2E+00
Cs-137	3.4E+00	2.9E+00	6.0E+00
Ba-140	2.4E+01	3.5E+00	3.5E+01
La-140	9.4E+00	1.2E+00	4.0E+01
Ce-141	4.2E+00	1.9E-01	1.1E+02
Ce-144	1.4E+01	4.9E+00	1.4E+01

A1.05 Soil

The LLDs in Table A.05 apply to the time of sample collection. Samples of approximately 200 g are counted for 5000 s.

Table A.05 Annual Dose at the LLD for Soil

Nuclide	*LLD (Bq/kg)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/kg)*
Cr-51	4.0E+01	2.5E-01	7.9E+02
Mn-54	5.8E+00	1.2E+00	2.5E+01
Fe-59	1.2E+01	3.1E+00	1.9E+01
Co-58	5.0E+00	1.1E+00	2.2E+01
Co-60	5.8E+00	3.2E+00	9.1E+00
Zn-65	1.3E+01	1.7E+00	3.9E+01
Zr-95	1.0E+01	5.1E+00	9.9E+00
Nb-95	6.0E+00	9.9E-01	3.0E+01
Ru-103	4.8E+00	5.1E-01	4.7E+01
Ru-106	4.6E+01	1.9E+00	1.2E+02
Ag-110m	5.2E+00	2.7E+00	9.7E+00
I-131	6.8E+00	5.2E-01	6.6E+01
Cs-134	5.2E+00	1.5E+00	1.7E+01
Cs-137	5.6E+00	7.1E-01	3.9E+01
Ba-140	2.2E+01	1.1E+01	9.6E+00
La-140	7.2E+00	*	*
Ce-141	6.8E+00	1.2E-01	2.8E+02
Ce-144	2.4E+01	2.9E-01	4.2E+02
TLD	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
*Dose for Ba-140 assumes equilibrium with La-140 (contribution from both)			

A1.06 Seawater

The LLDs in Table A.06 apply to the time of sample collection (for a 3.6 L sample counted for 5000 s for gamma; a 6 mL sampled counted for 100 min for tritium). The dose is small due to the simple facts that the Bay of Fundy is frigid at the best of times (occupancy factor is low) and no one drinks salt water.

Table A.06 Annual Dose at the LLD for Seawater

Nuclide	*LLD (Bq/L)*	*Dose at LLD (µSv)*	*Activity That Gives 5 µSv (Bq/L)*
H-3	2.4E+01	9.2E-11	1.3E+12
Cr-51	2.2E+00	2.6E-10	4.3E+10
Mn-54	2.8E-01	7.9E-10	1.8E+09
Fe-59	6.2E-01	2.6E-09	1.2E+09
Co-58	2.8E-01	9.1E-10	1.5E+09
Co-60	3.2E-01	2.4E-09	6.8E+08
Zn-65	6.8E-01	1.3E-09	2.6E+09
Zr-95	5.2E-01	1.2E-09	2.2E+09
Nb-95	3.0E-01	9.3E-10	1.6E+09
Ru-103	2.8E-01	4.4E-10	3.2E+09
Ru-106	2.6E+00	1.6E-09	8.3E+09
Ag-110m	2.6E-01	2.3E-09	5.7E+08
I-131	3.6E-01	2.3E-09	8.0E+08
Cs-134	2.6E-01	1.3E-09	1.0E+09
Cs-137	3.0E-01	5.2E-10	2.9E+09
Ba-140	1.2E+00	2.6E-08	2.4E+08
La-140	4.6E-01	*	*
Ce-141	4.0E-01	1.1E-10	1.8E+10
Ce-144	1.6E+00	2.7E-10	3.0E+10

* Dose for Ba-140 assumes equilibrium with La-140 (contribution from both)

A1.07 Clams

Typical LLDs are given in Table A.07 for the edible portions of clams, decay corrected to the time of sample collection. Samples are counted for 5000 s (size varies). The major assumptions are that the sample is taken at Dipper Harbour and that the level is maintained for the year.

Table A.07 Annual Dose at the LLD for Clams

Nuclide	*LLD (Bq/kg)*	*Dose at LLD (µSv)*	*Activity That Gives 5 µSv (Bq/kg)*
Cr-51	5.0E+01	2.0E-02	1.3E+04
Mn-54	7.0E+00	6.5E-02	5.4E+02
Fe-59	1.4E+01	3.1E-01	2.3E+02
Co-58	7.2E+00	1.3E-01	2.7E+02
Co-60	6.4E+00	1.8E+00	1.8E+01
Zn-65	1.4E+01	8.8E-01	7.8E+01
Zr-95	1.2E+01	1.5E-01	3.7E+02
Nb-95	6.6E+00	1.4E-01	2.3E+02
Ru-103	6.0E+00	5.5E-02	5.5E+02
Ru-106	5.8E+01	6.5E+00	4.5E+01
Ag-110m	5.8E+00	2.2E-01	1.3E+02
I-131	7.2E+00	9.5E-01	3.8E+01
Cs-134	6.6E+00	1.6E+00	2.1E+01
Cs-137	6.8E+00	1.5E+00	2.2E+01
Ba-140	2.4E+01	7.7E-01	1.6E+02
La-140	9.4E+00	2.2E-01	2.1E+02
Ce-141	7.4E+00	8.0E-02	4.6E+02
Ce-144	3.2E+01	2.6E+00	6.3E+01

A1.08 Fish

Typical LLDs are given in Table A.08 for the edible portions of fish, decay corrected to the time of sample collection. Samples are counted for 5000 s (size varies).

Table A.08 Annual Dose at the LLD for Fish

Nuclide	*LLD (Bq/kg)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/kg)*
Cr-51	1.3E+01	1.6E-02	4.0E+03
Mn-54	1.5E+00	5.1E-02	1.5E+02
Fe-59	3.8E+00	2.8E-01	6.8E+01
Co-58	1.5E+00	9.2E-02	8.0E+01
Co-60	1.4E+00	1.3E+00	5.4E+00
Zn-65	3.0E+00	7.0E-01	2.2E+01
Zr-95	2.2E+00	1.1E-01	1.0E+02
Nb-95	1.4E+00	1.1E-01	6.6E+01
Ru-103	1.5E+00	4.9E-02	1.5E+02
Ru-106	1.1E+01	4.4E+00	1.2E+01
Ag-110m	1.2E+00	1.7E-01	3.5E+01
I-131	7.8E+00	1.3E+00	3.1E+01
Cs-134	1.0E+00	1.2E+00	4.5E+00
Cs-137	1.4E+00	1.0E+00	7.1E+00
Ba-140	1.0E+01	7.8E-01	6.4E+01
La-140	4.6E+00	2.4E-01	9.6E+01
Ce-141	1.8E+00	6.0E-02	1.5E+02
Ce-144	5.8E+00	1.6E+00	1.8E+01

A1.09 Lobster

Typical LLDs are given in Table A.09 for the edible portions of lobster, decay corrected to the time of sample collection. Samples are counted for 5000 s (size varies).

Table A.09 Annual Dose at the LLD for Lobster

Nuclide	*LLD (Bq/kg)*	*Dose at LLD (µSv)*	*Activity That Gives 5 µSv (Bq/kg)*
Cr-51	3.0E+01	1.3E-02	1.2E+04
Mn-54	2.8E+00	2.1E-02	6.7E+02
Fe-59	9.0E+00	1.5E-01	2.9E+02
Co-58	3.2E+00	6.7E-02	2.4E+02
Co-60	3.8E+00	5.4E-01	3.5E+01
Zn-65	7.8E+00	3.4E-01	1.2E+02
Zr-95	5.4E+00	6.8E-02	4.0E+02
Nb-95	4.4E+00	9.0E-02	2.4E+02
Ru-103	4.0E+00	3.1E-02	6.4E+02
Ru-106	3.0E+01	2.4E+00	6.3E+01
Ag-110m	3.4E+00	8.8E-02	1.9E+02
I-131	1.7E+01	3.3E+00	2.6E+01
Cs-134	2.8E+00	6.4E-01	2.2E+01
Cs-137	3.4E+00	4.5E-01	3.8E+01
Ba-140	3.4E+01	1.2E+00	1.4E+02
La-140	1.2E+01	4.2E-01	1.4E+02
Ce-141	4.4E+00	4.3E-02	5.1E+02
Ce-144	1.3E+01	8.7E-01	7.4E+01

A1.10 Dulse

Typical LLDs are given in Table A.10 for dulse, decay corrected to the time of sample collection. Samples are counted for 5000 s (size varies). The major assumptions are that the sample is taken at Dipper Harbour and that the level is maintained for the year.

Table A.10 Annual Dose at the LLD for Dulse

Nuclide	*LLD (Bq/kg)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/kg)*
Cr-51	2.0E+01	2.4E-03	4.2E+04
Mn-54	3.4E+00	7.4E-03	2.3E+03
Fe-59	8.0E+00	4.4E-02	9.0E+02
Co-58	3.4E+00	1.5E-02	1.1E+03
Co-60	3.4E+00	2.1E-01	7.9E+01
Zn-65	8.2E+00	1.1E-01	3.9E+02
Zr-95	6.6E+00	1.6E-02	2.1E+03
Nb-95	3.6E+00	1.9E-02	9.5E+02
Ru-103	2.8E+00	7.1E-03	2.0E+03
Ru-106	2.6E+01	6.7E-01	2.0E+02
Ag-110m	3.0E+00	2.3E-02	6.4E+02
I-131	5.4E+00	3.0E-01	9.1E+01
Cs-134	2.8E+00	1.9E-01	7.3E+01
Cs-137	3.2E+00	1.3E-01	1.2E+02
Ba-140	1.6E+01	1.6E-01	4.9E+02
La-140	5.4E+00	2.8E-02	9.7E+02
Ce-141	3.4E+00	8.8E-03	1.9E+03
Ce-144	1.4E+01	2.4E-01	2.9E+02

A1.11 Sediment

The LLDs in Table A.11 apply to the time of sample collection. Samples weighing approximately 200 g are counted for 5000 s. The major assumptions are that the sample is taken at Dipper Harbour and that the level is maintained for the year.

Table A.11 Annual Dose at the LLD for Sediment

Nuclide	*LLD (Bq/kg)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/kg)*
Cr-51	1.7E+01	2.1E-01	4.2E+02
Mn-54	2.8E+00	7.9E-01	1.8E+01
Fe-59	6.2E+00	2.3E+00	1.3E+01
Co-58	2.6E+00	8.4E-01	1.5E+01
Co-60	2.8E+00	2.3E+00	6.1E+00
Zn-65	6.8E+00	1.3E+00	2.7E+01
Zr-95	4.8E+00	3.9E+00	6.1E+00
Nb-95	3.0E+00	7.2E-01	2.1E+01
Ru-103	2.4E+00	3.9E-01	3.1E+01
Ru-106	2.0E+01	1.5E+00	6.6E+01
Ag-110m	2.2E+00	2.1E+00	5.3E+00
I-131	3.4E+00	4.7E-01	3.6E+01
Cs-134	2.0E+00	1.2E+00	8.7E+00
Cs-137	2.8E+00	6.2E-01	2.3E+01
Ba-140	1.2E+01	1.0E+01	5.8E+00
La-140	3.8E+00	*	*
Ce-141	3.0E+00	8.9E-02	1.7E+02
Ce-144	1.1E+01	2.1E-01	2.7E+02
gamma meter	0.01 μSv/h	3.0E+00	1.7E-02

* Dose for Ba-140 assumes equilibrium with La-140 (contribution from both)

Appendix B: Sample Collection and Analytical Techniques

B1 Analytical Techniques

All environmental samples are analysed at the Health Physics Environmental Laboratory in Fredericton. The following pages provide a general summary of the analytical techniques used in the laboratory. Sample collection, preparation and analysis are briefly described, but can be found in detail in the laboratory procedures.

The major analytical techniques and the instruments used in routine environmental analyses are summarised in the Table B.01.

Table B.01 Summary of Analytical Techniques

Analytical Technique	Instrumentation
Gamma Spectroscopy	Canberra 24% efficient* intrinsic, Ge detector in an Applied Physical Technology 10 cm graded lead cave; Canberra S-100 MCA
Liquid Scintillation (tritium and C-14)	Beckman LS 6000TA Liquid Scintillation Counter
Gross Alpha/Beta (Wet Chemical Analysis for Sr-89 and Sr-90)	Tennelec LB-5100 Alpha/Beta Counting System
Gamma Surveys	Eberline Model FH 40G-10 low range gamma survey meter (range 10 nSv/h to 1 Sv/h for 30 keV to 3 MeV photons).
Thermoluminescent Dosimetry	Panasonic UD-710A Automatic TLD Reader and UD-814A1 ($CaSO_4$) dosimeters

*relative to a 3x3 inch sodium iodide detector

In gamma spectroscopy analysis, all significant peaks in the spectrum are identified either by reference to a database library of about 150 radionuclides, or by manual reference to compilations of all known radionuclides. In addition, approximately 20 selected radionuclides are specifically searched for in every sample with the exception of Air Iodine samples in which only I-131 is selected. The selected radionuclides include those that are produced in PLGS, and which would be readily detectable because of their abundance (high fission yield) and high branching ratios for gamma emissions. Naturally occurring gamma emitters, with the exception of Be-7, K-40 and Ac-228, are not included in this report. These excepted radionuclides are sometimes useful as general indicators of the consistency of the analytical techniques.

The peak search and analysis program SAMPO is used to process spectra. The library of radionuclides uses data of the Oak Ridge Laboratory. There are three categories of radionuclides evaluated:

1) selected nuclides of key fission and activation products
2) all other identified radionuclides, including natural radionuclides
3) detected energy peaks for which no identification can be readily made.

The three categories cover all possible eventualities in a spectral analysis and ensure that no significant radionuclides or photon energies will be overlooked.

The usefulness of gross alpha/beta analysis lies primarily in screening samples (to determine whether more detailed analyses should be performed) and showing trends. The reported alpha and beta values are assessed with respect to Am-241 and Sr-Y-90 calibration sources, respectively.

Wet chemical analysis for Sr-89,90 on Gaseous Effluent Monitoring (GEM) and Liquid Effluent Monitoring (LEM) samples follow the American Society for Testing and Materials procedure (using column chromatography).

Liquid samples, other than milk, are acidified upon receipt to keep radionuclides from plating out on the container walls. Perishable samples are refrigerated or frozen.

B2 Sample Collection and Analysis

B2.01 Airborne Particulates

Airborne particulates are collected on a 47 mm diameter Gelman Type A glass fibre filter, through which air is drawn at about 60 L/min (approximately 2400 m^3 for a 28 day continuous sample). The volume of air sampled is measured with an in-line integrating dry gas meter. Every month the filters are replaced and the used ones are returned to the laboratory for analysis. Sampling is therefore continuous throughout the year, the only interruption (other than power failure or pump breakdown) being the few minutes for a filter change.

Air particulate filters are analysed by gamma spectroscopy as soon as possible after collection to minimise loss of information through radioactive decay (ensure detection of any short lived gamma emitters that may be present, and to minimise any decay corrections). Samples are counted for 5000 s on the Ge detector.

Approximately three days after the end of the sample collection interval, each filter is counted for 100 minutes for the simultaneous determination of gross alpha and gross beta activities. Counting is delayed to allow for the decay of the short-lived radon progeny that would otherwise complicate the analysis.

If significant alpha/beta levels are detected (twice the normal level), further investigation is initiated (longer gamma counts or radiostrontium determinations).

If significant levels of Sr-89,90 (indicating 1% of Weekly DEL) are detected in the chemical analysis of Gaseous Effluent Monitor (GEM) filters, then the air monitoring station particulate filters are also to be analysed for these radionuclides.

B2.02 Airborne Radioiodines

Airborne radioiodines are collected in an activated charcoal cartridge placed downstream of the particulate filter. The cartridges are Nuclear Consulting Services NUSORB® (47 mm diameter and 48 mm length), containing 5% TEDA by weight. For a 28 day continuous sample approximately 2400 m^3 of air is sampled at a flow rate of about 60 L/min. The volume of air sampled is measured with an in-line integrating dry gas meter.

Iodine-131 is the major nuclide of interest on the charcoal cartridges. The cartridges are counted in groups of four for 50 000 s on the gamma spectrometer. Counts are performed as soon as possible after collection because of the relatively short-half life of I-131 (8 days). If radioiodines are detected, then the cartridges are re-analysed individually. Other fission product radioiodines, with much shorter half-lives (minutes to hours), decay before they reach the sample location or during the time the sample is being collected. If a significant release of radioiodines were noted from the station in this interval, the samples would be changed and analysed earlier to minimise errors from decay corrections.

B2.03 Airborne Tritium

A fraction of the flow in the air monitoring sample station is diverted through a molecular sieve container (Linde type 13X sieve material), to extract water vapour from the sampled air. Sample volume is measured with an in-line integrating dry gas meter.

Sampling is continuous at each location throughout the year, but is interrupted for a few minutes every month to exchange sieve containers. Since the amount of water absorbed by the molecular sieve from a given volume of air depends upon absolute humidity, flow rates are adjusted seasonally (using a Dwyer flow meter) to avoid saturation of the sieve material and to ensure adequate sample collection.

For tritium analysis by liquid scintillation counting, 6 mL of water taken from the molecular sieve condensate is counted for 100 minutes.

B2.04 Airborne Carbon-14

An aquarium pump bubbles air through 2N NaOH (1 L), into which carbon dioxide from the air is absorbed. Any C-14 as CO_2 is also absorbed.

Carbon dioxide, in the form of sodium carbonate, is regenerated by acidification and analysed for the determination of C-14 activity. The carbon dioxide is passed through a silica gel trap to remove moisture and tritium and then absorbed into the chemical Carbo-sorb® E until saturation is reached. After the addition of the scintillation cocktail Permafluor® E^+, the sample is analysed for 100 minutes by liquid scintillation counting.

B2.05 Environmental Gamma Radiation (TLD)

The environmental thermoluminescent dosimeter is composed of one element of natural lithium borate with no extra filtration, and three elements of calcium sulphate with lead filtration of about 700 mg/cm^2. The badge is sealed in plastic, placed in a screw cap plastic container and suspended about 1 m above the ground for a period of three months. This will measure the ambient gamma dose, whether it is from activity in the air, from the ground or cosmic in origin.

Readout is by the Panasonic UD-710A Automatic Reader. For typical quarterly measurements in the region of 150-200 μSv, measurements can be made to ±10% at the 95% confidence level.

B2.06 Soil

Soil samples are collected in undisturbed locations away from nearby buildings or trees. Level areas with some vegetation are preferred. A representative sample (approximately 1.6 kg) of the top 25 mm of a 20 cm by 20 cm area of soil is placed in a disposable polyethylene container.

The soil is dried on a disposable aluminum tray (at 80 °C) and sifted through a 0.5 mm sieve in the laboratory (a 1 mm sieve is used for coarse soils). Approximately 0.25 kg of dry soil is counted by gamma spectroscopy for 5000 s.

B2.07 Food

Garden produce and berries, which are either collected or purchased, require no special preparation. The edible portion is put in a calibrated container and weighed (size varies). This is counted by gamma spectroscopy for 5000 s.

B2.08 Milk

A 4L sample is purchased and placed in a clean polyethylene container.

For gamma spectroscopy, a 3.6 L aliquot is measured into a marinelli beaker. The remainder is distilled, and a 6 mL aliquot is analysed by liquid scintillation counting for 100 minutes. Count times are 50 000 s for gamma spectroscopy and 100 min for tritium analysis.

B2.09 Water

A 4L sample of well water, pond water, lake water or surface runoff is collected in a clean polyethylene container.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. After gamma analysis, well water samples (125-500 mL, depending upon the dissolved solids content) are evaporated to dryness on stainless steel planchets for gross alpha/beta analysis. For tritium analysis by liquid scintillation techniques, a 6 mL aliquot is analysed by liquid scintillation counting. For gamma spectroscopy, the sample is counted for 5000 s. For tritium and gross alpha/beta analyses, samples are counted for 100 min. A level twice the normal level for alpha/beta will initiate further investigation (longer gamma counts and/or Sr-89,90 analyses).

Measurements of gross alpha and beta are made about two weeks after sample collection. This delay avoids analytical interference from radon progeny whose activity is tied to that of the parent, which decays with a half-life of about 3.8 days. Natural radon and radon progeny occur in well waters everywhere and are known to reach high concentrations in many New Brunswick locations.

B2.10 Vegetation

The only vegetation types routinely collected and analysed are tree lichen (Spanish moss) and various ground mosses such as Cladonia and Lycopodium. They concentrate a wide range of radionuclides, both natural and man-made. This makes them sensitive indicators of radionuclides in the environment even though they are not identified in the pathway to man.

About 25 g or more of each of the samples is collected and air-dried before analysis. No special preparation is required. The sample is placed in a calibrated container and weighed. This is counted by gamma spectroscopy for 5000 s.

B2.11 Precipitation

Rain is collected continuously during the milder months.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. For tritium analysis by liquid scintillation techniques, a 6 mL sample of water is counted for 100 min. For gamma spectroscopy, the sample is counted for 5000 s.

B2.12 Sediment and Beach Surveys

Beach sediment samples are collected near the low tide mark, with preference being given to the top 10 mm of the fine sediment characteristic of tidal mud flats. A disposable polyethylene container is used to collect about 1 kg of sample. In addition, direct gamma radiation dose rate measurements are made at each sediment site using an Eberline Model FH 40G-10 low range gamma survey meter (range 10 nSv/h to 1 Sv/h for 30 keV to 3 MeV photons). The meter is held for one minute at a point one metre from the inter-tidal surface. After the sediment sample has been collected, this is repeated.

The sample is transferred to a disposable aluminum tray for drying at 80 °C. Dried, caked samples are broken into their original free granular form with a porcelain mortar and pestle, and sieved through a 0.5 mm mesh to collect the fines for analysis (a 1 mm sieve is used for coarse sediments). Approximately 0.25 kg of dried sediment is counted by gamma spectroscopy for 5000 s.

B2.13 Seafood

The inshore fishery throughout the Maritimes has declined since the OERMP was started in 1982. Some of it has been closed to any kind of harvesting. However, species of local seafood are collected when available from local fishermen. Sampling focuses on fish, lobsters and clams. Some of the areas where clam harvesting is prohibited are sampled with the permission of the Department of Fisheries and Ocean. Other seafood species are more mobile and can sometimes be found throughout the area: crab, periwinkles, aquaculture salmon, scallops, herring, mackerel, dogfish, cod, haddock, sea urchin, mussels, and flounder. The severe restrictions placed on the inshore fishery as well as the depletion of stocks make many of these samples unavailable most of the time (sometimes spanning years). However, whenever they are available an effort is made to collect as many samples as possible. Approximately 0.5 kg of fresh seafood is collected per sample.

Approximately 0.25 kg of each sample is prepared for gamma spectroscopy. Lobsters are cooked first, and the edible meat is removed for analysis. Clams, periwinkles, and crab are analysed whole, with a yield factor applied to account for the mass of the inedible shell. Usually the edible portion of fish is analysed, although sometimes the whole fish is analysed. Samples are counted for 5000 s.

B2.14 Aquatic Plants

Dulse (Rhodymenia palmata), an edible seaweed which is commercially harvested in the area, is collected monthly when available. Other species of seaweed concentrate a wide range of radionuclides, both natural and man-made. This makes them sensitive indicators of radionuclides in the environment even though they are not identified in the pathway to man.

A portion of the seaweed or dulse is put in a calibrated container and weighed (size varies). This is counted by gamma spectroscopy for 5000 s.

B2.15 Seawater

A 4L sample is collected in a clean polyethylene container.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. For tritium analysis by liquid scintillation techniques, a 6 mL sample of water is counted for 100 min. For gamma spectroscopy, the sample is counted for 5000 s.

If significant levels of Sr-89,90 (indicating 1% of Monthly DEL) are detected in the chemical analysis of the LEM composite, then the seawater is also to be analysed for these radionuclides.

B2.16 Miscellaneous Samples

This category encompasses all of those samples collected that do not fall within the other categories. It is a mechanism by which the lab can track and evaluate media for potential inclusion in the program. It gives the program flexibility and freedom and encourages the scientific curiosity of laboratory staff. A few of the media types started out this way. As many as 50 samples per year are analysed, including deer liver, mud puddles, snow, sea urchin and mussels.

B2.17 Bore Holes

A 4L sample of water is pumped out of the bore hole into a clean polyethylene container.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. For tritium analysis by liquid scintillation techniques, a 6 mL sample of water is counted for 100 min. For gamma spectroscopy, the sample is counted for 5000 s.

B2.18 Parshall Flume

PLGS staff collect a 4L sample of water from the Parshall flume systems.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. For tritium analysis by liquid scintillation techniques, a 6 mL sample of water is counted for 100 min. For gamma spectroscopy, the sample is counted for 5000 s.

B2.19 Hemlock Knoll Regional Sanitary Landfill

In December 1999, PLGS began disposing of its non-active waste at the public landfill facility. A monitoring program was established prior to the first shipment. It includes sampling of water from the leachate, bore holes and various holding ponds; sampling of the soil and gamma surveys of the disposal cell surface; and dosimeter placement at key locations.

Although some extra precautions are observed due to the potential biohazard of some of these samples, they are analysed according to established procedures previously described.

Appendix C: Location Codes

A 5m	PLGS Dry Fuel Storage Facility - 5 m NNE from perimeter fence
A 10m	PLGS Dry Fuel Storage Facility - 10 m NNE from perimeter fence
A 15m	PLGS Dry Fuel Storage Facility - 15 m NNE from perimeter fence
A 20m	PLGS Dry Fuel Storage Facility – 20 m NNE from perimeter fence
A 25m	PLGS Dry Fuel Storage Facility – 25 m NNE from perimeter fence
A 50m	PLGS Dry Fuel Storage Facility – 50 m NNE from perimeter fence
A 75m	PLGS Dry Fuel Storage Facility – 75 m NNE from perimeter fence
A 100m	PLGS Dry Fuel Storage Facility – 100 m NNE from perimeter fence
A 118m	PLGS Dry Fuel Storage Facility – 118 m NNE from perimeter fence
A01R	Bocabec – GPS Reading – L 45° 10.111N, Lo 67° 0.378 W
A02R	Bocabec – field across from A01R
A03R	Bocabec – inter-tidal zone
A04	Bayside – Fairmile Farm
A05R	Letete
A06	Digdeguash
A07	Beaver Harbour
A08	Back Bay
A09	Chamcook
A10R	Grand Manan
A12	St. Andrews

A11	Oak Bay / Waweig
AECL	Atomic Energy of Canada Ltd., Chalk River (QA)
B 5m	PLGS Dry Fuel Storage Facility – 5 m WNW from perimeter fence
B 10m	PLGS Dry Fuel Storage Facility – 10 m WNW from perimeter fence
B 15m	PLGS Dry Fuel Storage Facility – 15 m WNW from perimeter fence
B 20m	PLGS Dry Fuel Storage Facility – 20 m WNW from perimeter fence
B 25m	PLGS Dry Fuel Storage Facility – 25 m WNW from perimeter fence
B 50m	PLGS Dry Fuel Storage Facility – 50 m WNW from perimeter fence
B 75m	PLGS Dry Fuel Storage Facility – 75 m WNW from perimeter fence
B 100m	PLGS Dry Fuel Storage Facility – 100 m WNW from perimeter fence
B 150m	PLGS Dry Fuel Storage Facility – 150 m WNW from perimeter fence
B 200m	PLGS Dry Fuel Storage Facility – 200 m WNW from perimeter fence
B01	New River Beach - inter-tidal zone
B02	Pocologan
B03	New River Beach - park
B04	New River Harbour to Pocologan Harbour
B10	Pennfield
BAXR	Baxter's Dairy
BB	PLGS – Boiler Blow-down
BD	Belledune GS

C01	Lepreau Harbour – inter-tidal zone
C03	Lepreau
CCW	PLGS – Condenser Cooling Water Duct
CH	Chatham GS
COG	CANDU Owners Group
D01	Little Lepreau Basin - inter-tidal zone (remnants of clam shack)
D02	Little Lepreau
D03	Little Lepreau – GPS Reading – L 45° 08.030 N , Lo 66° 27.686 W
D04	Little Lepreau Basin – inter-tidal zone (remnants of boat wreck)
DH	Dalhousie GS
DOE	US Department of Energy (QA)
DUMP	PLGS – onsite landfill
DWC	PLGS – drinking water fountains
E01	Maces Bay –GPS Reading–L 45° 06.306 N, Lo 66° 28.651 W
E02	Maces Bay – Fundy Senior Citizens Centre
E03	Maces Bay – inter-tidal zone
E04	Maces Bay Cemetery
E05	Fundy Shores Elementary School – outside (Thompson/Trynor's Field)
E06	Fundy Shores Elementary School – inside
E07	Near intersection of route 790, Maces Bay Rd. and County Line Rd.
E11	28 Ridge Rd., Dipper Harbour

E12	22 Ridge Rd., Dipper Harbour
E13	16 Ridge Rd., Dipper Harbour
E14	10 Ridge Rd., Dipper Harbour
E15	4 Ridge Rd., Dipper Harbour
EDU	Edutech Enterprises
EPA	US Environmental Protection Agency (QA)
F01	Welch Cove–GPS Reading–L 45° 04.782N, Lo 66° 27.986 W
F02	Welch Cove – inter-tidal zone
F03	190 Welch Cove Rd., Maces Bay
F04	195 Welch Cove Rd., Maces Bay
F05	181 Ridge Rd., Maces Bay
F06	132 Ridge Rd., Maces Bay
F07	68 Ridge Rd., Maces Bay
G01	Indian Cove – inter-tidal zone
G02	Point Lepreau – lighthouse
G03	offshore – within 2 km of Point Lepreau lighthouse
G04	PLGS – inter-tidal zone 1 km south of CCW out-fall
GEM	PLGS – Gaseous Effluent Monitor
GL	Grand Lake GS
H01	Duck Cove – duck pond
H02	offshore – close to PLGS condenser cooling water out-fall

H03	Duck Cove - inter-tidal zone
H04	PLGS – across the road from old site of Information Centre building
H05	PLGS - start of nature trail near old site of Information Centre trailers
HS	Hanson Stream Reservoir
I00	PLGS SRWMF Phase 1– general site area
I01	PLGS SRWMF Phase 1
I02	PLGS SRWMF Phase 2
I03	PLGS SRWMF Phase 2 – general site area
I10A	PLGS SRWMF Phase 1 Bore Hole A (BHA)
I10B	PLGS SRWMF Phase 1 Bore Hole B (BHB)
I10C	PLGS SRWMF Phase 1 Bore Hole C (BHC)
I10D	PLGS SRWMF Phase 1 at I01 Barn (Shallow Bore Hole)
I10E	PLGS SRWMF Phase 1 at I01 Barn (Deep Bore Hole)
I10F	PLGS SRWMF Phase 1 Bore Hole southeast from C structure
I10G	FUTURE BORE HOLE
I10H	FUTURE BORE HOLE
I10I	FUTURE BORE HOLE
I11A	PLGS SRWMF Phase 1 - south fence (east side)
I11B	PLGS SRWMF Phase 1 - south fence (centre)
I11C	PLGS SRWMF Phase 1 - south fence (west side)
I11D	PLGS SRWMF Phase 1 - west fence (south side)
I11E	PLGS SRWMF Phase 1- west fence (centre)
I11F	PLGS SRWMF Phase 1 - west fence (north side)
I11G	PLGS SRWMF Phase 1 - north fence (west side)
I11H	PLGS SRWMF Phase 1 - north fence (centre)
I11I	PLGS SRWMF Phase 1 - north fence (east side)
I11J	PLGS SRWMF Phase 1 - east fence (north side)
I11K	PLGS SRWMF Phase 1 - east fence (centre)
I11L	PLGS SRWMF Phase 1 - east fence (south side)
I1A1	PLGS SRWMF Phase 1 – Cell 1A1
I1A2	PLGS SRWMF Phase 1 – Cell 1A2
I20A	PLGS SRWMF PHASE 2 – well #4 (shallow) BH4
I20B	PLGS SRWMF PHASE 2 – well #4 (deep) BH4
I20C	PLGS SRWMF PHASE 2 - well #7 (shallow) BH7
I20D	PLGS SRWMF PHASE 2 - well #7 (deep) BH7
I20E	PLGS SRWMF PHASE 2 – well #6 (shallow) BH6
I20F	PLGS SRWMF PHASE 2 - well #6 (deep) BH6
I20G	PLGS SRWMF PHASE 2 – well #5 (shallow) BH5
I20H	PLGS SRWMF PHASE 2 – well #5 (deep) BH5
I20I	PLGS SRWMF PHASE 2 – well #2 (shallow) BH2
I20J	PLGS SRWMF PHASE 2 - well #2 (deep) BH2
I20K	PLGS SRWMF PHASE 2 - well #3 (shallow) BH3

I20L	PLGS SRWMF PHASE 2 – well #3 (deep) BH3
I20M	PLGS SRWMF PHASE 2 – well #1 (shallow) BH1
I20N	PLGS SRWMF PHASE 2 – well #1 (deep) BH1
I20P	PLGS SRWMF PHASE 2 – north from bore hole 1
I20Q	PLGS SRWMF PHASE 2 – south from bore hole 2 (shallow)
I20S	PLGS SRWMF PHASE 2 – south from bore hole 2 (deep)
I20T	PLGS SRWMF PHASE 2 – north from bore hole 2
I20U	PLGS SRWMF PHASE 2 – well #8 shallow (BH8)
I20V	PLGS SRWMF PHASE 2 – well #8 deep (BH8)
I21A	PLGS SRWMF PHASE 2 – Periphery – south fence (east side)
I21B	PLGS SRWMF PHASE 2 - Periphery – south fence (centre)
I21C	PLGS SRWMF PHASE 2 - Periphery – south fence (west side)
I21D	PLGS SRWMF PHASE 2 - Periphery – west fence (south side)
I21E	PLGS SRWMF PHASE 2- Periphery - west fence (centre)
I21F	PLGS SRWMF PHASE 2 - Periphery - west fence (north side)
I21G	PLGS SRWMF PHASE 2 – Periphery – north fence (west side)
I21H	PLGS SRWMF PHASE 2 - Periphery – north fence (centre)
I21I	PLGS SRWMF PHASE 2 - Periphery – north fence (east side)
I21J	PLGS SRWMF PHASE 2 – Periphery – east fence (north side)
I21K	PLGS SRWMF PHASE 2 – Periphery – east fence (centre)
I21L	PLGS SRWMF PHASE 2 - Periphery – east fence (east side)

I70	PLGS – woods between plant & SRWMF
I71	PLGS - Near Plant Monitoring Well MW01-10, northeast from RB
I75	PLGS – north 73° east, 85 m from the stack (on pole)
I86	PLGS – 2nd pole from SRWMF driveway heading toward outer gate
I87	PLGS –3rd pole from SRWMF driveway heading toward outer gate
I88	PLGS – 4th pole from SRWMF driveway heading toward outer gate
I89	PLGS -5th pole from SRWMF driveway heading toward outer gate
I90	At distribution line on west side of Point Lepreau Rd.
I91	100 m north of distribution line on west side of Point Lepreau Rd.
I92	200 m north of distribution line on west side of Point Lepreau Rd.
I93	300 m north of distribution line on west side of Point Lepreau Rd.
I94	400 m north of distribution line on west side of Point Lepreau Rd.
I95	500 m north of distribution line on west side of Point Lepreau Rd.
I96	on the old Dupont warning sign at the end of the old "dynamite road"
I97	on the west side of the clearing at the end of the old "dynamite road"
I98	PLGS – north of SRWMF PHASE 2 (200 m north of transmission line)
I99	PLGS – north of SRWMF PHASE 2 – (100 m north of transmission line)
IAEA	International Atomic Energy Agency (QA)
J00	PLGS – south, 180 m from the stack (on fence)
J01	PLGS - Near Plant Monitoring Well MW01-1, near surge shaft
J02A	PLGS - Near Plant Monitoring Well MW01-2 (shallow), SSE from RB

J02B	PLGS - Near Plant Monitoring Well MW01-2 (deep), SSE from RB
J20	PLGS – south 19° east, 115 m from the stack (on fence)
J35	PLGS – south 34° east, 135 m from the stack (on sign)
J70	PLGS – south 69° east, 70 m from the stack (on pole)
K00	PLGS - Near Plant Monitoring Well MW01-3 south from RB
K01	PLGS – 95 m west of south gate leading to the lighthouse
K02	PLGS Cooling Water Pump-house – east fence near surge shaft
K03	PLGS - Near Plant Monitoring Well MW01-4 SSW from RB
K03C	PLGS sewage lagoon (chlorine contact tank)
K03E	PLGS inactive drainage (east lagoon)
K03W	PLGS inactive drainage (west lagoon)
K04	PLGS - Near Plant Monitoring Well MW01-5, WSW from RB
KDRP	KD Radpro
L01	PLGS – site of old cement plant
L02	PLGS – switchyard
L03	PLGS – outer security building (main gate)
L04	PLGS – construction stores
L05	PLGS - Near Plant Monitoring Well MW01-6, WNW from RB
L06	PLGS - Near Plant Monitoring Well MW01-7, paved staff parking lot
L07	PLGS - Near Plant Monitoring Well MW01-8, construction parking lot
L08	PLGS - Near Plant Monitoring Well MW01-9, N beyond fire training area

LAB	Fredericton – Health Physics Laboratory
LEM	PLGS – Liquid Effluent Monitor
M02	PLGS – Administration Building (2nd floor)
MISC	Miscellaneous locations
MQ	Mactaquac GS
N01	Dipper Harbour – GPS Reading – L 45° 05.399 N, Lo 66° 25.154 W
N02	Dipper Harbour – GPS Reading – L 45° 06.106 N, Lo 66° 24.949 W
N03	Dipper Harbour – GPS Reading – L 45° 05.551 N, Lo 66° 25.449 W
N04	Dipper Harbour – inter-tidal zone
N05	Dipper Harbour – beach behind restaurant
N06	Dipper Harbour – offshore
NTS	Nuclear Technology Services Inc. (QA)
P01	Chance Harbour – GPS Reading – L 45° 07.494 N, Lo 66° 21.456 W
P02	Little Dipper Harbour
P03	Liberty Hill – GPS Reading – L 45° 07.043 N, Lo 66° 21.498
P04	Round Meadow Farm
P05	Chance Harbour – 2 km offshore
PLGS	PLGS – general
Q01R	Lorneville
RPB	Radiation Protection Bureau, Health Canada (QA)
RPC	Research and Productivity Council

S00	Saint John and surrounding area
S10	Hammond River
SPL	Spruce Lake reservoir
TAYR	Taymouth
X03R	Fredericton - Chestnut Complex lab
X04R	Fredericton – reference seafood
X05R	Fredericton – reference milk test

X06R	West of Fredericton (Silverwood)
X10	Fredericton Junction – Atlantic Dairy Institute
X12	York Mills
Y#####	Hemlock Knoll Regional Sanitary Landfill

Appendix D: Abbreviations

AECL	Atomic Energy of Canada Limited
CCW	Condenser Cooling Water
CL	Critical Level
CNSC	Canadian Nuclear Safety Commission
COG	CANDU Owners Group
CSA	Canadian Standards Association
DEL	Derived Emission Limit
FWHM	Full Width Half Maxima
GEM	Gaseous Effluent Monitor
IAEA	International Atomic Energy Agency
ISO	International Organization for Standardization
LEM	Liquid Effluent Monitor
LLD	Lower Limit of Detection
LSC	Liquid Scintillation Counter
MSDS	Material Safety Data Sheet
NBEMO	New Brunswick Emergency Measures Organization
NIST	National Institute of Standards and Technology
NRC	National Research Council
NTS	Nuclear Technology Services
OERMP	Operational Environmental Radiation Monitoring Program
OPEX	Operating Experience
PLGS	Point Lepreau Generating Station
PROD	Power Reactor Operation Division
PSL2	Priority Substance List II
QA	Quality Assurance
QC	Quality Control
REPD	Radiation and Environmental Protection Division
RPB	Radiation Protection Bureau
SRWMF	Solid Radioactive Waste Management Facility
TLD	Thermoluminescent Dosimeter
USDOE	United States Department of Energy

Appendix E: Environmental Reports of Previous Years

PRE-OPERATIONAL (1976 - 1981)

Pre-Operational Environmental Radiation Monitoring Data for Point Lepreau Generating Station. October 1, 1976 to June 30, 1979. NBEPC-HP-79-1. J.A. Flanigan and J.J. Paciga. Sept. 1979.

Pre-Operational Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 1, 1979 to December 31, 1979. NBEPC-HP-80-1. J.A. Flanigan. Sept. 1980.

Pre-Operational Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 1, 1980 to December 31, 1980. NBEPC-HP-81-1. J.K. Sutherland and J.A. Flanigan. July 1981.

Pre-Operational Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 1, 1981 to December 31, 1981. NBEPC-HP-82-1. J.K. Sutherland. February 1982.

OPERATIONAL (1982 - 2001)

Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 01, 1982 (to 1997) to December 31, 1982 (to 1997). HP-07000-83 (to 98)-1. J.K. Sutherland. March 1983 (to 1998).

Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 01, 1998 (to 2001) to December 31, 1998 (to 2001). HP-07000-1999 (to 2002)-1. J.C. McCulley. April 1999 (to 2002).

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3. National Standards of Canada, *Environmental Management Systems - Specification With Guidance for Use (Adopted ISO 14001:1996) CAN/CSA-ISO 14001-96 (R2001)*, 1996.

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11. National Standards of Canada, *Guidelines for Radiological Monitoring of the Environment CAN/CSA-N288.4-M90*, 1990.

12. Bryant, P., *Methods of Estimation of the Dispersion of Windborne Materials and Data to Assist in Their Application*. UKAEA Report AHSB(RP)R42, 1964.

13. *External Beta/Gamma Dosimetry Program, HP-03541-2-TL Rev. 4*, Point Lepreau Generating Station Procedure Document, 2001.

14. *Environmental Radiation Monitoring Program Procedures, HP-03541-2-EN*, Point Lepreau Generating Station Procedure Document, 2001.

15. NBS Special Publication 456, *Measurements for the Safe Use of Radiation*, US Department of Commerce, 1976.

Appendix G: Distribution List

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